AN INVESTIGATION OF IMPLICIT AND EXPLICIT MEMORY IN COLLEGE STUDENTS AND HEALTHY OLDER ADULTS

By

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AN INVESTIGATION OF IMPLICIT AND EXPLICIT MEMORY IN YOUNG COLLEGE STUDENTS AND HEALTHY OLDER ADULTS

By

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Traditional measures of memory rely on explicit remembering, or the conscious recollection of information. Recently, attention has been focused on implicit memory, or learning which can be demonstrated indirectly without conscious retrieval. The implicit/explicit memory distinction is of particular relevance to the study of memory and aging, given this literature's emphasis on age-related impairments in conscious, strategic retrieval. Implicit memory for pre-existing representations in memory (e.g., words or idioms) has been well demonstrated in a wide variety of clinically amnestic patients and in older adults. Models developed from this literature have contributed to

our understanding of the relationship between encoding and retrieval processes. Implicit memory for newly learned associations, which have no pre-existing representation in memory, is not well accommodated by these models, but nevertheless is of great theoretical importance.

The present study investigated the effect of age on implicit and explicit memory for newly learned associations and old associations. Lexical decision and item recognition priming were employed as measures of implicit associative memory; item recognition accuracy and cued recall were used as explicit memory measures. In addition, the influence of automatic versus strategic processing at retrieval was investigated by varying the time available for memory search in the two associative priming tasks.

Age differences in implicit and explicit memory tasks varied in the predicted direction, indicating that older adults were more sensitive to the manipulations of retrieval demands than younger adults. The manipulation of time allowed for search also affected older adults differentially, suggesting that age differences were manifested as a disruption of strategic memory search. Finally, older adults demonstrated a bias toward processing well-learned semantic relationships, at the expense of processing novel information.

The specificity hypothesis is proposed to accommodate these data, and to provide a framework for future investigations of implicit and explicit memory distinction. This hypothesis states that the demonstration of learning is the result of a dynamic interplay between the specificity of the memory representation, the specificity of the retrieval cue, and the specificity required in the subject's decision or response.

CHAPTER ONE
INTRODUCTION

Experimental neuropsychologists and cognitive psychologists are fascinated by the many facets of memory. Various dissociable dimensions of memory functioning in normal subjects and patient groups are observed, measured, simulated, and modeled in the investigation of the normal and abnormal process. Understanding the nature of these dissociations in memory and the conditions under which they are masked or amplified is the challenge of the memory researcher.

The amnestic syndrome is particularly interesting to memory theorists because it accentuates dissociations that are much less apparent in normal memory. Anterograde amnesia is characterized as much by the profound disruption in new learning as it is by the sparing of immediate memory span, remote memory, general knowledge, and previously learned skills (Squire, 1982). In addition, recent studies indicate that amnestic patients show normal or near-normal ability to demonstrate learning of certain kinds of material, under certain conditions (Cohen, 1984; Graf, Squire and Mandler, 1984, Kinsbourne and Wood, 1975). These dissociations in memory, seen most clearly in acquired brain

disease, allude to the structure, processes, and organization of normal memory. Although there continues to be considerable controversy over the theoretical and anatomical implications of preserved learning in amnestics, most researchers agree that the investigation of spared and impaired memory abilities is central to understanding the nature of human memory.

Within this endeavor, research examining the role of conscious awareness in mnemonic processing has had considerable influence on our present conceptualizations of human memory. Traditional memory measures have relied on tasks requiring explicit conscious recollection of information acquired during a specific learning event. Word list learning and story recall are typical examples of explicit memory tasks. In contrast, new learning can also be demonstrated using tasks which do not require conscious remembering. These implicit tasks reflect prior learning in the form of savings across learning trials, alterations in response biases, and decreased response latency to previously presented stimuli.

The importance of awareness as a component of memory is highlighted in reports of dissociations between implicit and explicit memory in amnestic patients. These patients can demonstrate normal learning and retention on a variety of implicit memory tasks, while explicitly denying memory of the event in which this material was learned. Dissociation between memory with and without awareness has been reported

in amnestic and memory disordered patients of various etiologies.

The existence of such a dissociation suggests that implicit and explicit tasks involve distinct memory systems or processes which may be differentially vulnerable to the neuropathological changes occurring in memory disorders. In addition, fundamental questions are raised regarding the role of awareness in memory and the expression of knowledge.

The study of this phenomenon, and its implications for the neuropsychology of memory, has been pioneered entirely by investigations of clinically amnestic patients. However, the study of normal age-related changes in memory and cognition is being recognized as a valuable approach to to test theories of spared and impaired memory function. While healthy older adults do not exhibit the severe memory disorder seen in clinical amnesia, two important commonalities exist. First, the pattern of spared and impaired memory functions in older adults bears striking similarity to that observed in true amnesia. Immediate memory span or primary memory, fund of knowledge, and previously learned skills remain stable across the lifespan (Craik, 1977; Howard, 1983; Heaton, Grant, and Matthews, 1986). Considerably less resilient, however, is the type of mnemonic processing required on typical laboratory memory tests. Older adults perform well below younger controls when learning is incidental or intentional, under elaborative or nonmeaningful encoding conditions, and under

free recall, cued recall or recognition (Craik, 1977; Perlmutter and Mitchell, 1982; Poon, 1985). Paralleling studies of amnestic patients, several studies have recently shown that implicit memory performance is not affected by aging (Light, Singh, and Capps, 1986, Moscovitch, 1982; Howard, 1987; Rabinowitz, 1986; Light and Singh, 1987; Moscovitch, Winocur, and McLachlan, 1986). The existence of this dissociation between explicit and implicit memory in this population as well as other memory disorders suggests a fundamental vulnerability of explicit memory processes to the neuropathological changes occurring in both normal aging and various amnestic syndromes.

A second area of convergence is suggested in the neurobiology of memory dysfunction in aging and amnesia. Senile changes (cortical plaques, neurofibrillary tangles, and granuovacular degeneration) which characterize dementia of the Alzheimer's type, are present to a lesser extent in the brains of cognitively intact elderly (Bondareff, 1977). These cellular abnormalities as well as areas of cell loss are found primarily in the hippocampus, prefrontal and superior temporal regions of neocortex (Bondareff, 1977; Tomlinson, Blessed, and Roth, 1968). Memory changes occurring in normal aging may reflect gradual dysfunction of the corticolimbic system, which must be more severely affected to produce clinically significant amnesia.

This paper considers the contribution of the study of memory and awareness to current conceptualizations of

mnemonic processes, and tests hypotheses derived from this literature within the context of age-related changes in memory performance. Specifically, Chapter Two will review the implicit/explicit memory literature, discuss prominent models derived from existing experimental work, present the applications of this work to the study of memory and aging, and outline the pertinent research questions addressed by the present study. Chapter Three details the procedure used in the Lexical Decision and Item Recognition experiments, and Chapter Four presents the results obtained. The discussion in Chapter Five focuses particular attention on the retrieval demands in the two experimental procedures and the interaction between well-learned associations and new associations. A framework for conceptualizing the results obtained, as well as previous work, will be presented.

CHAPTER TWO
REVIEW OF THE LITERATURE

Memory Without Awareness in Amnesia

At a time when psychoanalytic views of unconscious memories and functional amnesia dominated the psychiatric literature, Korsakoff (1889) and Claparede (1911) provided the earliest anecdotal reports of memory without awareness in organic amnesia. As part of a conditioning experiment, both physicians subjected their amnestic patients to a noxious stimulus (an electric shock and a pin stick to the hand). At a later meeting, Korsakoff's patient expected his doctor to "electrify him" (Schacter, 1987, p. 504); Claparede's patient was reluctant to shake hands with him, declaring that "sometimes pins are hidden in people's hands" (Schacter and Tulving, 1982, p. 25). Neither patient could recall the episode in which these events occurred, and they could only provide a confabulated explanation for their apprehension. Korsakoff proposed that memory traces were formed after the onset of the amnestic syndrome. Although these traces were unavailable to consciousness, Korsakoff believed that they affected ongoing behavior (Korsakoff, 1889, as cited in Schacter, 1987).

Procedural Learning

The first clear experimental demonstrations of memory without awareness are found in studies of the bitemporal amnestic patient, H.M. Despite this patient's profound anterograde amnesia, he clearly showed savings in mirror tracing (Milner, Corkin, and Teuber, 1968), tactual maze learning (Corkin, 1965), rotary pursuit performance, perception of Gollin Figures (Corkin, 1968; Milner et al., 1968), and complex puzzle solutions (Cohen and Corkin, 1981). While H.M. required more trials to criterion than control subjects and performed more slowly on motor tasks, he demonstrated savings which stood in marked contrast to his inability to explicitly recall the experience of learning. Milner et al. (1968) also described examples of H.M.'s residual learning in everyday life. For example, fourteen years after the surgery, H.M. had learned the arrangement of rooms and furniture in his house. Milner et al. observe that, "just as in the test situations, these achievements appear to depend on frequent repetition of the items and their embedding in a constant framework" (pg. 232). They did not indicate whether this everyday example of residual learning capability was reported explicitly by H.M. or inferred indirectly through his behavior at home.

Subsequently, motor, perceptual, and cognitive skill learning have been reported in profoundly amnestic patients of various etiologies, including Korsakoff's disease, encephalitis, anoxia, ruptured anterior communicating artery

aneuyerism, and closed head injury (Brooks and Baddeley, 1976; Cermak, Lewis, Butters and Goodglass, 1973; Cohen, 1984; Cohen and Squire, 1980; Moscovitch, 1982; Wood, Ebert and Kinsbourne, 1982). Many of these skills were maintained over extended periods of time, and, typically, the patients did not remember the practice sessions in which the skills were acquired (Cohen, 1984).

Direct or Repetition Priming

Extending these observations of preserved memory function in amnesia, Warrington and Weiskrantz (1968, 1970, 1974) reported that amnestic patients exhibited retention of words and pictures using a variation of a cued recall test. In their experiment, subjects first studied a list of words or a set of pictures. Later, the memory test consisted of the initial letters of studied words or studied items in degraded form which subjects were required to identify. Control subjects and amnestic patients produced an equivalent number of correct responses using this technique, while dramatic differences were obtained using standard free recall and recognition tests.

Graf, Squire, and Mandler (1984) determined that the demonstration of preserved memory using partial information hinges upon a subtle instructional manipulation. In their experiments, subjects were given the first three letters of a previously studied word which they were asked to complete with the first word that comes to mind. Word stem completion for control subjects and amnestic patients were

compared with cued recall performance in which subjects used similar word stems as cues to aid recall of studied items. The results indicated that allowing the amnestic patient to use unconscious retrieval (by asking them to complete word stems with the first word that comes to mind) was critical to demonstrating preserved memory performance.

This direct or repetition priming has been observed in amnestic patients in the form of increased probability to complete word stems with previously studied items (Graf, Squire and Mandler, 1984), alterations in free association responses (Shimamura and Squire, 1984), facilitation of reaction time to previously presented words in a lexical decision task (Gardner, Boller, Moreines and Butters, 1973; Scarborough, Cortese and Scarborough, 1977; Moscovitch, 1982), reductions of reading speed for previously studied items (Moscovitch, et al., 1986), alteration of spelling bias by presenting homophones (Jacoby and Witherspoon, 1982), and modifying preference judgements for previously presented melodies (Johnson, Kim and Risse, 1985). Amnestic patients demonstrated learning at normal or near normal levels when memory was assessed using these implicit measures, while they performed well below controls on explicit memory tests for the same material.

These findings raised questions regarding the relationship between explicitly and implicitly demonstrated learning. Several investigators (Graf, Mandler, and Haden, 1982; Graf and Mandler, 1984; Jacoby and Witherspoon, 1982)

reported that manipulations that typically affect explicit recognition and recall (e.g., semantic encoding) do not influence performance on implicit memory tests such as word stem completion or perceptual identification. These findings have lead some to postulate that the implicit and explicit memory represent two independent forms of memory (Cohen, 1984; Schacter, 1987; Tulving, 1972 and 1983). Others have emphasized that, in normal subjects, implicit memory contributes to explicit remembering (Jacoby, 1983 a and b; Mandler, 1980; Shimamura and Squire, 1984).

The interaction between implicit and explicit memory was demonstrated by Graf, Squire, and Mandler (1984). They reported that amnestic patients' recognition performance, while considerably lower than normal subjects, was above chance. The decay of recognition performance for both amnestic and normal subjects paralleled the decay of word completion, with the amnestic subjects reaching chance level in both word completion and recognition after two hours. This indicated that priming contributed to recognition performance in both groups, but this effect was short-lived, and normal subjects were able to augment their performance with explicit remembering.

Temporary repetition priming is also thought to account for amnestic subjects' ability to learn strongly related paired associates. Shimamura and Squire (1984) reported that amnestics showed near-normal explicit memory for recently presented related word pairs at immediate testing;

however, this learning decayed to baseline over two hours. Control subjects maintained the associations beyond the two hour interval. In addition, a recent study by Mayes, Pickering and Fairbairn (1987) suggested that amnestic patients' susceptibility to proactive interference in a A-B, A-C paired associate learning paradigm may be the result of temporary priming. In their experiment, subjects rated A-B pairs, then A-C pairs. In a free association test, amnestics and normals produced the same number of B list intrusions in response to A items. In explicit recall, amnestics produced the same number of intrusions while control subjects produced fewer intrusions.

These studies suggest that if the systems or processes underlying implicit and explicit memory are fundamentally different, they work in tandem in the normal individual and may account for quantitative and qualitative differences across memory tasks in amnestic patients.

<u>Indirect Priming and Priming of Existing Representations</u>

The implicit memory findings reported thus far share a common property in that most demonstrate priming effects within the same modality of presentation and all depend on perceptual processing the stimulus at learning and retrieval. Priming can also occur across modalities and in the absence of perceptual encoding. Graf, Shimamura and Squire (1985) reported that priming of word stem completion (with visually presented word stems) occurred in both normal and amnestic subjects regardless of whether the target words

were learned auditorily or visually. Within modality priming was significantly larger than cross modality priming in both groups. This indicated that specific perceptual information contributed considerably to the priming effect; nevertheless, the cross modality priming provided evidence that a higher order representation of the stimulus was activated as well. Additional evidence for nonperceptual factors in priming was provided in a study by Shimamura and Squire (1984). Shimamura and Squire (1984) presented words (e.g., baby) for study in an incidental learning task. They then had subjects free associate to words that were related to studied words (e.g., child). The probability of producing a previously presented and related word was significantly higher than baseline free association for both control and amnestic patients. These data suggest that the presentation of a word activates its semantic associates even though semantic associations were not presented or emphasized at encoding.

Priming of New Associations

Many interpretations of repetition priming in amnestics considered this spared function a manifestation of the activation of previously stored representation (Cermak, 1984; Diamond and Rozin, 1984; Tulving, 1983). Strong evidence for this view was reported in a study of priming for nonwords (Cermak, Talbot, Chandler and Wolbarst, 1985). Normal subjects show priming for previously studied nonwords (which can be assumed to have no prior representation in

memory), while Korsakoff patients do not. These findings fit neatly within the view of preserved implicit memory in amnestics as a temporary activation of unimpaired semantic memory (Cermak, 1984; Tulving, 1972 and 1983).

However, this view was challenged by Schacter and Graf (1986). In their experiment, subjects studied unrelated word pairs in paired associate format (e.g., window--reason). Subjects then completed word stems which were presented with cues that either were studied with the target word (window--rea_____) or not studied with the target (mold--rea_____). When the subjects were told to complete the stems with the first word that came to mind, both normal and amnestic patients responded with targets more often under the same cue condition (window--rea___) than under the different cue condition (mold___). In contrast, when their instructions were to complete the same stems with a word that was studied previously, amnestic patients showed no effect of prior study or study context and performed well below normals. These data indicated that their amnestic subjects showed implicit memory for word pairs that had no preexisting association but were recently associated in a paired-associate task.

Schacter (1987) and others (Schacter and Graf, 1986; Graf and Schacter, 1987; Shimamura, 1986) argued that these data indicate that implicit memory in normals and amnestic patients extends beyond the activation of preexisting representations in memory. However, the nature of priming

for newly learned associations has remained unclear. Graf and Schacter identified features of associative word completion that set it apart from word completion for single words. First, elaborative encoding strategies aimed at forming a meaningful association between the two unrelated words was required to elicit priming for new associations. Second, Graf and Schacter's (1987) reexamination of their data revealed that only mild to moderately impaired amnestic patients exhibited priming for newly learned associations. This stands in contrast to priming of preexisting associations (single words and old associations), which can be demonstrated in severely amnestic patients.

Could implicit memory for information which has no preexisting representation in memory be a reflection of explicit memory? Schacter and Graf (1986) and Graf and Schacter (1987) argued against this interpretation by pointing out that the memory-impaired subjects performed much poorer under explicit cued recall instructions than under implicit word completion instructions. Thus, these patients apparently were not using explicit remembering to complete the word stems. In addition, normal subjects denied using explicit strategies to complete the word stems, and they did not show higher completion rates during the second half of the task (which might indicate that subjects were "catching on" and using explicit memory to aid their completion).

Schacter and Graf also point out ways in which word completion for new associations is unlike explicit cued recall performance for the same associations. For example, priming for new associations is insensitive to the type of elaborative encoding (generating a sentence relating the two words versus rating a sentence regarding how well it related the two words), or to proactive or retroactive interference. In summary, priming for newly formed associations shares qualities with both explicit memory for new associations and implicit memory for single words.

Shimamura (1986) and Graf and Schacter (1987) propose that priming for newly formed associations represents a different type of implicit memory. Shimamura suggests that forming a new association requires a minimal level of elaborative encoding, but once this has occurred, the association can be accessed via implicit retrieval procedures in memory impaired subjects and normals. Normals would be expected to augment this encoding and under explicit retrieval conditions show good recall. Presumably, the basic level of encoding which mild to moderately impaired amnestics are capable of performing is still insufficient for reliable explicit remembering.

Schacter (1987) and Graf and Schacter (1987) support the view that the processes involved in the priming of new associations are fundamentally different from those underlying repetition priming or explicit memory. Thus, the minimal level of elaborative encoding required to

demonstrate priming for new associations is not simply a weakened normal elaborative encoding. They point out that the demonstration of implicit memory for new associations requires that some portion of the target response be presented. For example, if subjects study window-reason, and the association between the two words is later tested via word completion, subjects must be shown window--rea_____ in order to generate the correct target; window--______ does not produce priming. A similar constraint to this "new learning" is seen when amnestics are taught new associations via the method of vanishing cues (Glisky, Schacter, and Tulving, 1986). In each case some part of the target item must be presented to elicit the target response. Thus, the encoding underlying these new associations is "hyperspecific". Schacter (1987) accounts for this hyperspecificity by asserting that priming of new association must rely to some degree on the activation of a preexisting representation.

These findings, then, suggest that (1) implicit memory for new information, unlike priming for single words or previously acquired representations, requires a minimal level of elaborative processing as well as incomplete disruption of neurobiological substrate of memory; (2) the retrieval of this information through implicit means is not sensitive to certain factors (interference, type of elaborative encoding) which are known to influence explicit retrieval; (3) the formation of new associations in memory

impaired individuals is "hyperspecific", relying heavily on the retrieval environment to activate preexisting representations (Schacter, 1985).

Theories of the Implicit/Explicit Memory Dissociation

While the significance of the dissociation between implicit and explicit memory performance is widely accepted, the theoretical basis for its existence continues to be debated. Many researchers argue that the dissociation reflects separate memory systems, for example episodic versus semantic memory (Cermak, 1984; Tulving, 1972 and 1983), procedural versus declarative memory (Cohen, 1984; Cohen and Squire, 1980), or perceptual versus autobiographical memory (Jacoby and Dallas, 1981). Each multiple memory system model points out an interesting and important aspect of implicit/explicit performance differences, but none has been able to account for the existing data adequately (Schacter, 1987). Much of the inadequacy in existing theories can be attributed to the failure to appreciate differences between various implicit memory tasks (Moscovitch, 1984; Moscovitch et al., 1986). Various investigators have recognized this deficiency and have attempted to approach the implicit/explicit memory distinction by more carefully analyzing the processing demands of various implicit and explicit memory tasks (Graf and Mandler, 1984; Graf and Schacter, 1987; Jacoby, 1983 a and b; Moscovitch et al., 1986; Shimamura, 1986; and Schacter, 1985 and 1987). The common element of these views

is the assumption that implicit and explicit memory tasks reflect a single internal representation of the memory event. Different cognitive processes (and neurobiological systems) are assumed to contribute fundamentally different components to the representation. While a consensus has not been reached regarding the parameters which modulate the formation and access of the representation, the current approach appears to have broader implications for memory theory in general.

Activation and elaboration. Studies demonstrating direct or repetition priming suggest that preexisting mental representations can be "activated" during learning making it more likely that studied items would be produced or identified when partial information was provided at test (Rozin, 1976). An activation explanation of normal priming in amnesia is supported by studies demonstrating that normal subjects exhibit priming for recently studied nonwords (which presumably have no previous representation in memory), while amnestic subjects do not (Cermak, 1984; Diamond and Rozin, 1984).

Extending Mandler's (1979, 1980) model of recognition processes, Graf and Mandler (1984) interpret implicit and explicit memory task differences in terms of two types of processing which can occur at encoding: activation and elaboration. In their view, activation is an automatic process by which the internal organization of an existing representation (or schema) is further integrated or

strengthened, increasing its accessibility. This intraitem integration focuses on the "perceptual, featural, and intrastructural aspects of the event...independent of its relations to other events and representations" (Mandler, 1980, p.255). Conscious elaboration, on the other hand, makes a representation or schema more retrievable by establishing meaningful relations with other mental events, thereby creating an identifiable context. Elaboration allows for the generation of new as well as the reinforcement of old retrieval paths.

At encoding these two processes contribute to different components of the internal representation of the memory event. Activation and its consequence, integration, create the perceptual component of the memory representation, and elaboration produces the semantic or conceptual component. According to this model, "the dissociation between recall and word completion performance is due to the utilization of different kinds of information [at retrieval] derived from a single underlying representation" (Graf and Mandler, 1984, p. 553). Thus, in normal subjects, the experimenter must mask the explicit memory component of the implicit task in order to engage the subject in processing which will be sensitive primarily to perceptual component of the memory representation. The neuropathology of amnesia, however, eliminates explicit recollection as a means of retrieving an item from memory by disrupting the elaborative process and hence the formation of the conceptual/contextual components.

Studies of indirect priming indicate that viewing implicit memory in terms of activation of primarily perceptual attributes of a memory representation is too restricted. Semantic properties of a representation must be activated as well. This criticism does not invalidate the activation/elaboration hypothesis, but would require a modification to allow for the activation of general meaning information. This modification does not seem unreasonable given that amnestic subjects can access the meaning of a word when it is presented, and that basic meaning information can be accessed rapidly without specific contextual referents (e.g., in reading).

Another limitation of the activation hypothesis is its failure to allow for temporary perceptual modifications of a representation via the intraitem integration process. The automatic integration process, as described by Graf and Mandler (1984) only allows for the strengthening of existing features of a representation; modification of features is not accommodated by the model. Roediger and Blaxton (1987) have demonstrated that the temporary influence of highly specific featural information about a stimulus (e.g., typeface) can be demonstrated via perceptual identification. They reported that words presented at a brief exposure duration are identified more readily if they are printed in the typeface that was used at study. Information regarding typeface would not be expected to be contained in a preexisting representation of a word. Clearly, this

indicates that highly unique and specific perceptual features are being incorporated into a representation. Since this incorporation of specific featural information decays rapidly (unless repeated), it would not be maladaptive to the maintenance of a stable store of information.

The activation/elaboration approach also has difficulty accounting for implicit memory for newly learned associations. Since elaborative encoding is required to demonstrate priming for new associations, it is unclear why this encoding would not allow for explicit retrieval. One possibility, perhaps accommodated by the activation-elaboration model, would consider priming of new associations in mild amnestic as a reflection of a weakened, but not completely disabled, elaboration process. Thus, a poorly elaborated association relies heavily on the supportive retrieval environment characteristic of implicit memory tasks. Even so, this explanation cannot account for Graf and Schacter's results; differences in their mild amnestic patients' word stem completion performance was attributable to a manipulation of instructions, not the type of retrieval cue.

Schacter (1987) proposes that priming of new associations is aided by, although not entirely dependent on, automatic activation of preexisting representations. According to this view, the requirement that some part of the target response must be provided for priming of new

associations to occur, indicates that an activation process is supporting the effect. Schacter does not clearly resolve the critical question of how preexisting representations and new associations interact. Neither does he provide a convincing explanation of the manner in which implicit versus explicit instructional manipulations determine priming effects in memory disorder subjects. The nature of implicit memory for new associations and its relationship to explicit memory processes and preexisting associations needs to be investigated further.

Processing approach. Jacoby and colleagues (Jacoby and Dallas, 1981; Jacoby, 1983a and b), and Roediger and Blaxton (1987) support a model that also focuses on the processing demands characterizing implicit and explicit memory tasks. Like Graf and Mandler, proponents of the processing approach interpret performance differences on implicit and explicit tasks as reflecting the interaction of encoding and retrieval demands. The nature of this interaction determines how a single underlying representation in memory is formed and expressed.

Jacoby (1983b) elegantly demonstrated this interaction in a study of implicit and explicit memory in normals. In his experiment, he varied encoding conditions by having subjects read a target word alone (e.g., cold), read a target word in the context of its antonym (e.g., hot--cold), or generate a target word as an antonym of a stimulus word (hot ???). Processing at retrieval was manipulated by

probing memory with a typical recognition test and a perceptual identification task. Perceptual identification involves presenting target words and nonstudied words at a brief exposure duration; the dependent variable is proportion of studied versus nonstudied words that are read by the subject.

Jacoby reported that in recognition testing, words learned in the generate condition were remembered better than those encoded in the context condition, which in turn were better remembered than words encoded alone. The opposite results were obtained in the perceptual identification task: words encoded alone were identified at a higher probability than words presented in context, and words presented in context were identified at a higher probability than generated words. In fact, the probability of perceptually identifying a word which was generated was not significantly different from the probability of identifying a new word.

Jacoby proposes that encoding and retrieval operations vary along a continuum of data-driven and conceptually driven processing. Data-driven processing involves the formation and access of a perceptual code in the representation of an episode. Conceptually driven processing establishes and retrieves the conceptual and contextual codes within the same representation. At encoding these processes contribute to different components of a representation of a memory event. According to Jacoby,

performance on a memory task depends on both the nature and match of processing occurring at both encoding and retrieval. The performance differences on implicit and explicit tasks reflect the degree to which data-driven or conceptually driven processing is engaged at encoding and retrieval.

Unlike Graf and Mandler, Jacoby rejects the notion that priming depends on the activation of an existing schema or representation in memory. Instead, he argues that highly specific episodic representations are formed during encoding. At retrieval, implicit (data-driven) tasks are more sensitive to the perceptual components of the representation, while explicit (conceptually driven) tasks are more sensitive to the contextual and meaningful components. Roediger and Blaxton (1987) emphasize that data-driven and conceptually driven processing should be considered a continuum with many memory tasks involving both operations to greater or lesser degrees.

This processing approach is recognized as an elaboration of Tulving and Thompson's (1973) concept of "encoding specificity" and Morris, Bransford and Franks' (1977) notion of "transfer appropriate processing". As such, there is no distinction between types of processing that result in "good" or "bad" memory, but instead, successful demonstration of learning is determined by the degree to which the activity at retrieval emulates the activity at encoding.

While data-driven processing accounts for the highly specific and episodic nature of a memory representation (Roediger and Blaxton, 1987), Jacoby's restricted use of the perceptual identification task has resulted in a limited conceptualization of implicit memory (Shimamura, 1986). Like Graf and Mandler's activation process, Jacoby limits data-driven processes to the perceptual components of a memory representation; indeed, the perceptual component is most likely to be accessed by the perceptual identification task. This type of task, however, would not be sensitive to a minimal level of semantic or "conceptual" analysis which, according to studies of indirect priming, occurs automatically at encoding as well (i.e., data-driven conceptual processing).

Possibly a more damaging criticism of Jacoby's model is its exclusive emphasis on the episodic nature of the memory representation, i.e., that each memory experience forms a specific representation rather than activating an abstract representation in memory (Schacter, 1987). Studies that have demonstrated the sensitivity of perceptual identification to subtle alterations in physical characteristics of the stimuli (Roediger and Blaxton, 1987) certainly indicate that unique, episodic information can be encoded and retrieved implicitly. However, this assertion does not adequately recognize the critical role of preexisting representations in priming. If a unique, episodic representation is formed by data-driven processes,

it also contains perceptual and semantic components derived from the activation of a previously stored representation which may include semantic/conceptual information.

The processing approach's emphasis on the formation of a detailed episodic representation of a memory event might accommodate the priming of newly learned associations. However, amnestics lack of priming for nonwords is more problematic, since it is assumed that this failure results from the absence of a representation in memory. Thus, again Jacoby's model must account for the strong evidence that preexisting representations may contribute to the formation of new representations in memory.

In summary, Graf and Mandler (1984), Graf and Schacter (1987), Schacter (1987) Jacoby (1983 a and b, 1984) and Moscovitch et al. (1986) agree that implicit and explicit retrieval draw upon the same underlying representation. Dissociations between implicit and explicit memory tasks reflect the complex multicomponent nature of the representation and processing demands with differing sensitivities to the various components. Less clear is the nature of this representation and the interaction between it and the processes which form and access it (i.e., types of encoding, implicit and explicit retrieval demands). In addition, the nature of implicit memory for new associations remains unclear. Its occupies a puzzling borderzone between typical repetition priming and explicit remembering.

Our efforts to understand the implications of the implicit/explicit distinction rests on research efforts to (1) examine the processing demands of various implicit and explicit memory tasks; (2) examine the nature of implicit memory for preexisting and new associations; and (3) to continue to explore these processes in various forms of memory dysfunction.

Implicit and Explicit Memory in Normal Aging

Studies conceptualizing older adults' memory difficulties in terms of the distinction between implicit and explicit memory are a relatively recent contribution to the literature. Perhaps because there exists a fundamental process underlying all forms of anterograde memory dysfunction, the findings reported to date in older adults parallel those reported in amnestics. In addition, theories of implicit and explicit memory discussed above share many of the same constructs with existing conceptualizations of age-related memory changes.

Direct or Repetition Priming in Older Adults

Given that profoundly amnestic patients demonstrate normal priming for single words (repetition priming), memory and aging researchers anticipated that older adults would exhibit this type of priming as well. This expectation has been supported. Older adults show normal benefit from prior exposure on implicit tasks such as perceptual identification (Light and Singh, 1987), word fragment completion (Light, Singh and Capps, 1986), and lexical decision (Moscovitch,

1982), while their explicit memory for the same material is impaired relative to younger adults. These findings have been used to support age-related impairments in specific contextual encoding (Light and Singh, 1987) and effortful, deliberate, self-initiated retrieval processes (Craik, 1985; Howard, 1987). The integrity of older adults' semantic memory (preexisting representations) is also demonstrated by intact repetition priming (Howard, 1987).

Implicit Memory for New Associations

More recent efforts have focused on implicit memory for new associations for several reasons. Such priming effects reflect the formation of a new representation in memory or a substantial and specific modification of existing representations. Studies of associative priming in amnestics suggest that priming magnitude for new associations is affected by some factors that affect explicit memory (e.g., elaborative encoding, degree of memory impairment), but not others (e.g., type of elaborative encoding, retroactive and proactive interference) (Schacter and Graf, 1986; Graf and Schacter, 1987). Older adults' well-documented deficiency in using (or benefitting from) elaborative encoding strategies and in forming new associations under explicit memory conditions raises the question of whether age differences would be found in implicit memory for new associations.

The two studies that have examined associative priming in elderly subjects applied paradigms developed by McKoon

and Ratcliff (1979) and Ratcliff and McKoon (1978) for studying associative priming in young college students. McKoon and Ratcliff (1979) had subjects study related and unrelated word pairs for later cued recall. One group of subjects then performed word-nonword decisions on target words of prime-target pairs, some of which had been previously studied. The other group performed a recognition judgement on target words of the same prime target pairs. McKoon and Ratcliff reported that subjects in both lexical decision and item recognition conditions showed priming between newly learned word pairs.

Drawing upon this study and other work by the same authors (Ratcliff and McKoon, 1981), Rabinowitz (1986) reasoned that the magnitude of priming in implicit associative memory might reflect the degree to which older adults had integrated the two members of a pair in memory. If older adults are impaired in integrating novel associations, then large age differences in priming magnitude would be expected for unrelated studied pairs, and small or absent age differences in priming would be expected for related studied pairs. In this study, younger and older subjects studied related and unrelated word pairs for later cued recall testing. Each pair was presented for 5 sec. Before cued recall testing, subjects were shown single items and they were required to respond (as quickly as they could) "yes" if the item had been studied and "no" if it had not (item recognition). Words in this item recognition priming

task were either primed (preceded by the word that it was studied with) or unprimed (preceded by a word that it was not studied with). If an association has been formed the primed trials should lead to faster decisions than the unprimed trials. This difference between the primed and unprimed trial is the priming effect.

Rabinowitz found that older adults' explicit memory (recognition accuracy and cued recall) performance was significantly worse than younger adults for both related and unrelated word pairs. However, there were no age differences in the amount of priming for either related or unrelated pairs. (Both younger and older subjects exhibited larger priming effects for related than unrelated pairs).

Rabinowitz argued that the absence of age differences in priming effects is inconsistent with the view that older adults fail to adequately integrate novel information in memory. Instead, these results support a deficit in deliberate, effortful retrieval and a "conscious evaluation stage", along with a corresponding increase in their reliance on automatic processes.

A study by Howard, Heisey, and Shaw (1987) evaluated priming of new associations by presenting unrelated word pairs for study within sentences (e.g., the dragon sniffed the fudge). This method allowed them to determine whether older adults (like younger adults) encode sentences as nondirectional propositions by testing forward and backward priming. More relevant to the present discussion, they

manipulated study time between groups, allowing 15 sec. per sentence in the short study condition and an additional 10 sec. presentation in the long study group. As in Rabinowitz's (1986) study, an item recognition task was used to examine associative priming and explicit memory was tested via cued recall. Howard et al., reported that older adults did not exhibit priming for studied pairs under short study conditions. With extended study, both younger and older subjects exhibited equivalent priming in terms of magnitude and bidirectional (forward and backward) effects.

Howard et al. concluded that older adults require more study time to establish new associations than younger controls. Given this additional time, however, older adults exhibit automatic activation of the new association in a similar manner as younger subjects.

Theories of Age-Related Memory Deficits

Interpretations of dissociations between implicit and explicit memory in normal aging are couched within existing conceptualizations of age-related changes in memory. The views presented here are not only influential in the current thinking of memory and aging, but they are also particularly relevant to the study of implicit memory phenomenon in general.

Automaticity of processing and retrieval. One popular conceptualization of age-related memory changes is that distinguishing automatic and effortful or strategic processing (Hasher and Zacks, 1979). Automatic processing

occurs rapidly outside of our awareness, does not demand attentional resources, and is not affected by aging. Effortful or strategic processing is slower, deliberate, requires attentional resources. Automatic processing is sufficient for encoding the "flow of information" such as physical characteristics of a stimulus or frequency of occurrence information, but effortful processing is required for meaningful encoding, bringing strategies to bear on a memory problem or deliberate retrieval of specific information. Proponents of this view argue that older adults become less able to engage in this type of processing or, alternatively, this type of processing becomes less efficient with age.

The essential difference in retrieval demands of implicit and explicit memory tasks has been characterized in terms of a distinction in the degree to which conscious effortful processes are required at retrieval (Howard, 1987; Rabinowitz, 1986). This interpretation is largely based on a two-process model of retrieval (e.g., Baddeley, 1982; Klatsky, 1984). Retrieval can occur through a passive, automatic or "direct match" process in which attributes of a stimulus rapidly access the representation in memory. Alternatively, a slower, deliberate search strategy can be initiated following conceptually organized associations. As described above, Howard (1987) proposed a general deficiency in this deliberate search process with aging, affecting

retrieval of both well learned (semantic) and newly learned material.

The automatic-effortful processing continuum has been an influential construct within the memory and aging literature. This processing continuum is implied, if not directly stated, in the process/activation theories of implicit and explicit memory as well. Activation or data-driven processing is viewed as a rapid, automatic process which is determined entirely by the stimulus and its representation in memory, rather than by a strategy adopted by the subject. Elaboration or conceptually driven processing is slow, deliberate, requiring attentional resources and is subject to the individuals' (or experimenters') imposed strategies for processing information. Investigators studying preserved memory function in amnestics often acknowledge the apparent significance of conscious awareness in characterizing the implicit/explicit memory distinction; however, they do not emphasize automaticity and effort as a useful explanatory construct. This difference in emphasis between the amnesia literature and the memory and aging literature most likely reflects the intuitive appeal within the latter field of a age-related reduction in "mental energy" paralleling the reduction in physical energy (Craik and Byrd, 1982).

Although this construct has wide appeal in the aging literature, there has been considerable disagreement over the criteria used to independently classify tasks as

"automatic" or "effortful". This difficulty may reflect the tendency to view processing demands as a dichotomy rather than a continuum, as well as the problem of circular reasoning (i.e., characterizing age-related memory deficits as impaired effortful processing, and in turn defining effortful tasks as those which older adults show impairment). Despite these problems, many investigators (e.g. Shiffrin and Schneider 1977; Craik and Byrd, 1982) have recognized that degree of automaticity characterizes a fundamental aspect of mnemonic processing. Whether this construct has more than descriptive value remains to be determined. The implicit/explicit memory paradigm provide the memory and aging research with a new method of examining this issue.

<u>Semantic memory and general versus specific encoding</u>. Studies comparing older and younger adults with respect to word association (Howard, 1983), semantic priming (Howard, McAndrews, and Lasaga, 1981), and knowledge of scripts (Light and Anderson, 1983) attest to the stability of the contents and organization of semantic memory over the lifespan. Indeed, older adults often perform better than younger adults on tests of vocabulary and general information, reflecting the benefit of their rich semantic networks. They do not, however, benefit from encoding procedures which emphasize semantic attributes or relationships in to-be-remembered stimuli. This presents an apparent paradox: older adults, despite their superior

fund of semantic knowledge, exhibit a particular impairment in semantic encoding.

Rabinowitz and Ackerman (1982) argue that this paradox is resolved when considering the types of errors older adults commit on memory tasks. On a recognition test, older adults will choose semantically related distractors more often than younger adults, whereas false positives for unrelated distractors occur equally in younger and older adults (Rankin and Kausler, 1979). In similar studies Perlmutter (1979) and Rabinowitz and Ackerman (1982) had subjects generate words in response to target words. Later, younger adults showed a clear advantage in recall when they were cued with words they had previously generated. Older adults showed no advantage of their own cues over general category labels or cues derived from published word-association norms. Rabinowitz and Ackerman conclude that older adults encode global or general semantic attributes of new information, while younger adults encode specific, unique features of the stimulus. The effect of encoding specific features allows younger adults to discriminate a memory representation from other similar representations in memory. It can be argued that discriminability is an essential attribute of a retrievable memory representation.

Older adults' tendency toward general semantic encoding may occur by virtue of a bias toward processing information in terms of similarity or overlap with past experiences. Older adults may process new information in a manner

redundant with existing knowledge, rather than distinctive from existing knowledge. This routinized inflexibility of processing is consistent with the stability of crystalized intelligence and the decrease in fluid intelligence over the lifespan (Horn, 1982).

Although Rabinowitz and Ackerman interpret this problem of nonspecific processing as occurring at encoding, it is clear that this same processing bias could be active at both encoding and retrieval. Nonspecific encoding would create nondistinctive memory representations; nonspecific retrieval would create interference among many related representations in memory.

This conceptualization has not been applied to the implicit/explicit memory distinction; however, aspects can be understood within implicit/explicit models developed in the amnesia literature. First, a shared assumption is that explicit remembering is highly dependent on distinctive, contextually relevant components of a memory representation. Second, processing which is assumed to be inaccessible or of limited value in explicit remembering is characterized as relying heavily on a temporary activation of preexisting information. This activation contributes to components of a memory representation which (because they are relatively nondistinctive) can only be reliably accessed via implicit memory measures. Older adults' encoding of information in a general manner might be viewed as analogous to the basic level semantic analysis that can occur via activation or

data-driven processing. Thus, normal implicit memory in older adults may tap this processing bias toward preexisting representations which occurs at the expense of contextually distinctive information.

Questions Raised by the Aging and Memory Literature

In summary, older adults, like mild amnestics, can exhibit "normal" priming for newly learned associations, despite their impairment in demonstrating this new learning explicitly. The Howard et al. data imply that older adults may not encode these associations in an entirely normal fashion since they require a longer study time to show priming for new associations. However, both Rabinowitz (1986) and Howard et al. (1987) emphasize the role of an automatic/unaware process in older adults' spared implicit memory performance and interpret explicit memory deficits as manifestations of impaired conscious, deliberate retrieval.

Several interesting issues are raised by their conclusions. First, both investigators based their interpretations on an item recognition paradigm which, like explicit recognition testing, requires a conscious memory decision. Although the dependent variable (reaction time) is an indirect measure of association between the two items, this measure also reflects a conscious evaluation regarding the target item's status as a previously studied word. Given their emphasis on conscious retrieval, a more careful investigation of implicit associative priming in older adults would utilize a task in which the response does not

require a conscious memory decision. Second, the fact that these investigators were able to demonstrate priming using the item recognition procedure raises the question of why a failure in conscious retrieval would affect typical yes/no recognition testing, but not item recognition priming (which requires the same response but under speeded conditions). Successful application of the implicit/explicit paradigm to the study of memory and aging will depend on more critically evaluating processing demands and their interactions using various implicit and explicit memory tasks.

Summary of Implicit and Explicit Memory Literature

The body of research reviewed in this paper may raise as many questions as it answers. However, the existing data permit certain conclusions to be drawn: (1) Implicit and explicit memory tasks access different components of a single underlying representation of a memory event; (2) One type of encoding/retrieval process, termed activation or data-driven, forms/accesses components of a new memory representation which are characterized by perceptual information about the stimulus, and a basic level of featural and semantic information that is influenced by preexisting representations in memory; (3) A second type of encoding/retrieval process, elaboration or conceptually driven, forms/accesses distinctive semantic and conceptual components of the representation (e.g., contextual cues, retrieval plans); (4) The first process is obligatory, occurring rapidly and automatically on presentation of a

stimulus, the second process may or may not occur, depending on the deliberate use of strategies; (5) The priming of new associations appears to require both types of processes, as it shares characteristics of more typical forms of implicit and of explicit memory; (6) On any memory measure, the manifestation of learning will depend heavily on the degree to which the retrieval processes match or emulate the processes that occurred at encoding; (7) Task demands may restrict both the type of processing engaged by the individual as well as the degree of match occurring at encoding and retrieval; (8) Healthy younger adults use both activation/data-driven and elaboration/conceptually-driven processes, often simultaneously; (9) Patients with substantial disruption of the corticolimbic memory system are able to perform the first process normally, but this process typically does not yield components of a representation that are accessible to explicit memory; (10) Older adults make errors in memory which suggest that their representation of a memory event is based heavily on preexisting representations, with minimal distinctive contextual information; (11) Studies of implicit memory in older adults suggest that they can form memory representations which incorporate new relationships, but these representations, like those of mild amnestics, are inflexible and highly dependent on the retrieval environment; (12) Mild amnestics and normal elderly are able to perform the activation/data-driven process normally,

but their errors in memory also reflect inefficient elaborative processing by virtue of an incomplete lesion to the corticolimbic memory system.

Theoretical questions raised by the implicit/explicit memory literature emphasize how subtle retrieval processing variations can elucidate aspects of a memory representation and the processes which may have occurred at encoding (Schacter, 1987; Shimamura, 1986; Moscovitch, 1984; Moscovitch, et al., 1986). Further investigation of priming of new associations may be a particularly useful vehicle for understanding age-related memory failures and the implicit/explicit memory distinction. Research to date examining this phenomenon has been limited. As mentioned above, the only studies of associative priming in older adults used a paradigm which requires a conscious, explicit memory decision (item recognition). Current conceptualizations of age-related memory dysfunction (general versus specific encoding, automatic versus effortful retrieval, the role of semantic memory or preexisting representations in the processing of new information) are well suited for evaluation using the implicit memory methodology. Comparing implicit memory for preexisting associations and new associations using tasks which vary in their retrieval demands will allow for a more careful analysis of older adults' processing deficits.

Experimental Rationale and Hypotheses

The application of the implicit/explicit memory paradigm to the study of age-related memory changes is new. The present study was conceptualized as a broad exploratory investigation which allowed for the evaluation of several issues raised by the literature. Four conceptual domains were explored: (1) the nature of age differences and similarities in implicit and explicit memory for new associations; (2) the role of varying retrieval demands in contributing to age differences and similarities in implicit and explicit memory tasks; (3) the influence of automatic and strategic processing at retrieval in determining age differences and similarities; and (4) the specific contribution of old, well learned associations to information processing in older and younger subjects.

The present investigation examined retrieval demands by using lexical decision and item recognition priming procedures and cued recall. These memory probes were chosen for the following reasons. First, the encoding demands and stimuli can be equated (i.e., subjects study the same list of related and unrelated word pairs). Second, in both priming tasks, a prime word would be expected to facilitate a decision regarding the target word if an association exists between the two words. Third, the degree to which explicit retrieval processes are required to access this association differs across the three tasks. Lexical decision requires subjects to decide whether the target word

is a real word or a nonsense word. Thus, facilitation between a prime and target reflects the association between the two words, without a conscious memory decision. In contrast, in item recognition, subjects must decide if the target is a previously studied word. In this case, the facilitation between a prime and target is still an indirect measure of memory since the dependent variable is reaction time not accuracy; however, the reaction time does reflect the contribution of a conscious memory decision. Item recognition accuracy reflects a direct measure of memory; although the retrieval demands are limited since the target word is fully presented for evaluation by the subject. Cued recall requires the highest degree of explicit remembering since the subject must search and retrieve an item in response to a cue. The comparison of lexical decision priming and item recognition priming allowed for a more careful analysis of age-related processing differences occurring at retrieval.

Automatic and strategic processing in retrieval was examined more closely within these priming procedures by controlling the time between the onset of the prime word and the onset of the target word, or stimulus onset asynchrony (SOA). A short SOA (150 msec.) would be expected to prevent the subject from initiating a search of memory for the target in response to the prime word. A long SOA (900 msec.) would allow for such a search to be initiated, and the potential existed for subjects to correctly anticipate

the target if the search was successful. Comparing these two conditions was proposed as a method to elucidate age differences in automatic and strategic search of memory. There has been considerable debate regarding the efficacy of SOA manipulation in controlling processing; the manipulation of SOA was nevertheless included with these considerations in mind.

The effect of age on the processing of new and old associations was examined by using semantically related and unrelated words to form the paired associate word pairs and corresponding prime-target pairs. The priming procedures allowed for the examination of newly formed associations and well learned associations under varying retrieval demands and under automatic and strategic processing conditions. Age was expected to effect the processing of related and unrelated word pairs differently with respect to these proposed age sensitive variables.

Measures of implicit and explicit memory for single words was also included in the experiment. Implicit memory for single words is a robust finding in severe amnestics as well as older adults. If older adults failed to demonstrate priming for newly learned associations but showed intact implicit memory for single words, then conclusions could be drawn regarding specific age-related impairments in the formation of associations. Perceptual identification was employed as the implicit measure and two-item forced choice was chosen as the explicit memory measure.

Hypotheses

Hypothesis One: Age differences in the formation of new associations were expected to vary with the retrieval demands required by the tasks. Older and younger adults were expected to perform similarly in the Lexical Decision experiment because the demonstration of memory was not dependent on explicit retrieval. Older adults were expected to show smaller priming effects than younger adults in the Item Recognition experiment because younger adults would use conscious retrieval effectively to facilitate their reaction times. Item recognition accuracy would show moderate age differences, again reflecting younger adults' more effective explicit memory. The largest age differences were expected in the cued recall task reflecting older adults' inefficient explicit search and retrieval of a specific item in memory.

Hypothesis Two: Age differences were expected to be manifested as a disruption of strategic memory search (in decreased accuracy or reaction time) when, under the long SOA conditions, older adults are given sufficient time to initiate a search. When the SOA is short, promoting an automatic retrieval process, age differences were expected to be small or nonexistent.

Hypothesis Three: Age differences in processing of old associations were expected only in the condition in which old associations and new associations were in conflict. Older adults were predicted to show priming for the old associations (supporting their general semantic encoding

bias), while younger adults would not show priming (because they would be expected to form more distinctive new associations).

Hypothesis Four: Based on the weight of previous findings, age differences would not be expected for perceptual identification of single words; however, age differences would be expected for recognition of single words.

CHAPTER THREE
METHODS

Lexical Decision Experiment

Subjects

Younger adults. Fifteen University of Florida undergraduate students (8 females and 7 males) were each paid $10.00 to participate in the experiment. Each subject was right handed and reported English as their native language. Mean age was 22.6 years with a range of 19 to 27 years. Mean years of education and WAIS-R Vocabulary scaled scores were 14.3 and 12.6 respectively.

Older adults. Fifteen community dwelling older adults (6 males and 9 females) were also paid $10.00 for their participation in the study. They were recruited through a newspaper advertisement and met the following criteria: (1) high school education, (2) negative history for neurological disease, alcohol abuse, head injury, seizure disorder, stroke, significant coronary artery disease, and uncontrolled hypertension; and (3) self report of good current health status. Mean age was 67.2 years with a range of 61 to 77 years. The older adults' mean years of education and mean WAIS-R Vocabulary scaled score were not significantly different from that of the younger adults

(13.0 and 12.6 respectively). Although older adults show a trend toward lower Verbal Fluency Scores than younger adults, the differences were not significant. Table 3-1 summarizes these subject characteristics.

Table 3-1. Mean Years of Age and Education, WAIS-R Vocabulary Scale Scores, and Verbal Fluency Scores for Younger and Older Adults in Lexical Decision Experiment.

Group	Age	Education	Vocabulary	Fluency
Younger	22.6 (19-27)	14.2 (13-17)	12.5 (10-16)	46.0 (33-68)
Older	65.0 (60-72)	13.1 (12-17)	11.3 (8-18)	43.4 (27-50)

Note: Verbal Fluency Scores are the sum of correct responses generated in 60 seconds for each F, A, and S letter stimulus.

Design

Lexical decision priming paradigm. The experimental design was a 2 (group) by 4 (priming condition) by 2 (SOA) mixed factorial design. Group was the only between subjects variable. Priming condition and SOA were within subject variables. The four priming conditions were: (1) Studied Old Associations, (2) Studied New Associations, (3) Non-Studied Old Association and (4) Unprimed. Word-nonword prime-target pairs were included as well, but reaction times for these decisions were not included in the analyses. Table 3-2 presents a sample study and test trial to illustrate the four pair types. SOA was varied randomly

Table 3-2. Sample Study-Test Trial for Lexical Decision Priming.

Study Pairs (n=10)		Prime-Target (Test) Pairs (n=18)		
METAL	BENCH	METAL	DATCH	(N)
CANNON	ASSAULT	PARLOUR	BEACH	(F)
HATE	LOVE	OPERA	VIOLIN	(2)
OPERA	VIOLIN	SWEET	POVE	(N)
PRISON	BLADE	ATTEMPT	LONELY	(4)
BREAD	BUTTER	TABLE	CHAIR	(3)
CAPTAIN	LONELY	INVENT	TORTURE	(4)
VICIOUS	TORTURE	BARK	VICIOUS	(F)
PARLOUR	CHAIR	BREAD	BUTTER	(1)
SPORT	BEACH	FAME	PRISON	(F)
		KNIFE	BLADE	(3)
		MONDAY	POVENT	(N)
		HATE	LOVE	(1)
		CANNON	ASSAULT	(2)
		NEEDLE	SHREAT	(N)
		SPORT	FIME	(N)
		NOBLE	CAPTAIN	(F)
		GRIN	BONCH	(N)

Note: 1=Studied Old Associations, 2=New Associations, 3=Non-Studied Old Associations, 4=Unprimed, F=Filler, and N=No responses.

across test lists with the constraint that half of the test lists utilized a 150 msec. SOA and half used a 900 msec.

SOA. SOA was defined as the time from the onset of the prime word to the onset of the target word. Each subject studied 20 lists of 10 word pairs. A test list of 18 prime-target pairs immediately followed each study list. The pairs and lists were randomized for each subject. Each of the four priming conditions were represented twice in each test list. This yielded twenty potential observations for each priming condition at each SOA for each subject.

Cued recall test. Every set of five study-test trials was separated by a cued recall test. This cued recall test used ten pairs in the five previous study trials (two from each study list). Five of these pairs were from the Studied Old Asscociations, and five were from the Studied New Associations priming condition. Thus, half were semantically related and half were unrelated, and all pairs chosen were paired at both study and test. The right hand word of the pair was presented on a sheet of paper followed by a blank line. The subject was required to respond with the word that was paired with presented word in the study list. Subjects were strongly encouraged to guess if they were uncertain. Items in the cued recall tests were randomized (as they were based on the randomization of the study-test lists) for each subject.

Single item memory tasks. Following the last cued recall test each subject performed a perceptual identification task and a two-item forced choice recognition

test. Stimuli for each of these tasks consisted of forty targets and forty distractors. None of the words chosen had been used in the Cued Recall test. Two left hand words of a pair (one from a semantically related pair and one from an unrelated pair) were selected from each study list to form the pool of target items. The pool of distractor items were words never presented during the experiment. Stimuli for the perceptual identification task and the two item forced choice task were counterbalanced across subjects such that each item was represented equally in each test.

Materials

Three hundred and sixty word pairs were formed. All items were common words between three and eight characters in length. McKoon and Ratcliff's (1979) published prime-target pairs constituted two hundred and eighty of the word pairs used. The remaining 72 pairs were chosen from Thorndike and Lorge (1944) and Webster's Pocket Dictionary, and were similar in length, commonality and ease of associativity. These extra pairs were used as fillers or restricted to primes of word-nonword trials which were not part of the main analyses of interest. Nonwords were created from filler items by replacing vowels or consonants with randomly chosen vowels or consonants. Of the three hundred and sixty word pairs, one hundred and twenty were semantically related and two hundred and forty were pre-experimentally unrelated. As determined by McKoon and Ratcliff (1979), the unrelated pairs were easily associated

with study, but the preexperimental association between them was not sufficient to produce priming between the first and second words without prior study. The materials also included a set of extra words to be used in the multiple choice and perceptual identification tests, as well as pronounceable nonwords. The extra words were chosen to conform to the length and commonality characteristics of the main pool of word pairs.

Study and test list construction, randomization, stimulus presentation, and data collection were controlled by an IBM PC/XT microcomputer. The main pool of word pairs and the pronounceable nonwords were divided into groups (Primacy, Studied Old Associations, Studied New Associations, Non-Studied Old Associations, Unprimed, Nonwords, Fillers, Recency). Unrelated word pairs that made up the Studied New Associations and the Unprimed priming conditions were represented equally in the two conditions, as were the related pairs that formed the Studied Old Associations and the Non-Studied Old Associations. Words in the non-experimental groups (Primacy, Recency, Filler, and Nonwords) remained in these groupings for all subjects.

Words for a given trial were chosen in the following manner. One item from the Primacy group and one item from the Recency group were chosen randomly without replacement and assigned to position one and ten in the study list. Two items from each of the four priming conditions were chosen

randomly without replacement and placed randomly in the study list. Items in the Non-Studied Old Association and the Unprimed conditions were linked to items in the Recency, Fillers, and Nonwords groups to recombine word pairs to conform to the specific priming condition. For example, the pair "PARLOUR CHAIR" was linked with the Recency pair "SPORT BEACH" such that on the test list the pairs "TABLE CHAIR", "PARLOUR BEACH", and "SPORT FIME" were created.

The primary constraint on the construction of the test lists was that prime-target pairs placed in the first position of the test list were always "no" responses (i.e, word-nonword pairs). This constraint was used so a "yes" response (which would be used in the analyses) would not be in the Primacy or Recency portion of the test list. The eight experimental test list pairs and their linked four word-nonword and four filler word-word pairs were placed randomly in positions 2 through 17. Thus, the test list consisted of twelve "yes" responses and six "no" responses. While a equal number of "yes" and "no" responses would have been desirable, it was decided that increasing the number of test items to achieve this balance would have proved overwhelming for subjects. As the primary analyses of interest concerned only correct yes responses, it was felt that this imbalance would not adversely effect the results. Refer to Table 3-2 for a sample study-test list construction. For a given subject twenty study-test lists were constructed.

Procedure

Each subject was tested individually. Following a brief explanation of the experiment and an inquiry regarding health history, each subject read and signed an informed consent form. The subject sat facing an Amdek A 300 amber monitor and was shown the right and left shift keys which were labeled "yes" and "no" respectively. A Yes/No practice trial began each test session. The subject was given the following instructions: "To get you accustomed to responding on the computer you will see the word 'yes' or 'no' printed in the center of the screen. When you see the word 'yes' press the right key, labeled 'yes', with your right index finger. When you see the word 'no' press the left key labeled 'no' with your left index finger. You are to respond as quickly and accurately as you can. Rest your fingers on the keys so you can respond quickly. Ready?" Twenty such yes/no trials were presented.

The practice study-test list followed the Yes/No practice. Subjects were given the following instructions: "This is a study of memory. You will be studying pairs of words. In the center of the screen you will see word pairs presented one pair at a time. Read the two words out loud and then do whatever you can to try to remember the two words together. You can say them to yourself over and over, or make a sentence in your mind, or think of the two words as pictures and relate them together. Do whatever will help you remember them together as a pair, because later I will

give you the first word and want you to come up with the second word. You will see 10 such pairs in one study list. Let's go through a practice study list. Remember say the words out loud and try to remember them together as best you can." The word "READY?" is presented in the center of the screen. The examiner hit the "return" key to begin the* study list presentation. Ten word pairs, printed in capital letters, were presented in the center of the screen for five seconds each with a one second interstimulus interval. Subjects were corrected for misreading a word and prompted for forgetting to read a word aloud.

After studying the practice study list, subjects were given the following instructions: "Now you will see a test list. In the center of the screen you will see a first word followed immediately by a second word. If the second word is a real word, respond 'yes' by hitting the 'yes' key. If the second word is a nonsense word, respond 'no' by hitting the 'no' key. Respond 'yes' or 'no' as quickly and accurately as you can. Remember you only have to respond to the second word and you have to decide if that word is a real word or a nonsense word. After we go through this practice test list you will see what I mean. Rest your fingers on the 'yes' and 'no' keys to be ready to respond. Ready?"

The words "Ready for Test?" were presented in the center of the screen and the examiner hit the 'return' key to begin the test list presentation. The prime was

presented in the center of the screen for 100 msec., followed by either a 50 or 800 msec. blank screen, then followed by the target word or nonword presented in the center of the screen. The target remained on the screen until the subject made a response. Once the response was made the next prime was presented 1 sec. later. Eighteen such prime-target pairs were presented. Subjects' performance was monitored during the practice session and correction was provided if necessary. It was stipulated that subjects would take the practice test again if it was apparent that they did not understand the instructions; however, this was not necessary with any subject. Data was not collected during the practice trial.

After this practice trial the following instructions were given: "As you noticed some first and second words were ones you studied together and some were not. Also some of the words made sense together and some did not. Your job, though, was to respond yes or no as fast and accurately as you could whether the second word was a real word or a nonsense word. At different points during the experiment, I will also be testing your memory for the word pairs on a paper and pencil test. You will be given the first word and you will need to write down the word that you studied with it. So it is very important that you try to remember the word pairs. Now, there are twenty study-test lists like the one you just did. We will take a break after every five study-test lists so you can rest. Ready for the first study

list? Remember, read the words out loud and try to remember them together as best you can." The experimental study-test lists were presented in the same manner as the practice list. Prior to each test list the subject was reminded to place his/her fingers on the response keys if necessary. The computer recorded the subject's reaction time and response. Subjects were not given feedback regarding their responses.

After every five study-test trials, subjects were given a cued recall test. Ten word pairs (one related pair and one unrelated pair from each of the five study lists) were selected by the computer and printed out. The right hand of each pair was printed in capital letters followed by a line. Subjects were given the following instructions: "This paper has first words from pairs in the lists you just studied. Write down the words that went with them. If you can't remember one please guess because many times guesses are correct. So try to write a word down for each one even if you are unsure or just guessing." After he/she was finished and allowed to stand and stretch, the next five study-test trials were presented. After the second cued recall test (at the halfway point) subjects were encouraged to take a 10 minute break and walk about. No subject took a break lasting longer than ten minutes.

After the final cued recall task the subjects performed a perceptual identification task. They were instructed as follows: "This is a test of perceptual speed or how fast

your brain can understand what you see. In the center of the screen you will see a row of hatch marks. The hatch marks will be replaced by a word and the word will be quickly crossed out by a row of "X's". All you have to do is to try to read the word. Now, the word will be presented for a very brief time so you will need to pay close attention to the screen. If you cannot read the word try to make a guess. Sometimes people can figure out part of the word and then make a guess. Please make a guess even if you are not sure. Ready?" Eight number symbols (########) were presented to the center of the screen for five seconds. A word then replaced the number symbols for a specified length of time (described below) followed immediately by eight "X"'s (XXXXXXXX) for two seconds. The first ten words were distractors (not previously presented words) presented in a descending series from 110 msec. to 20 msec. The eleventh through fiftieth words were both targets and distractors presented for 20 msec. each in a pseudorandom order. The subject's responses were recorded down by the examiner. This protocol for exposure duration was standard for all Young Adults. In a pilot screening of the procedure it was apparent that many older adults would not be able to perform the task at such rapid exposure durations. Therefore two alternate exposure duration series (60 or 90 msec.) were employed for older adults. The sixty msec. exposure duration started with the first ten filler words presented in descending series from 170 to 60 msec. If the

older adult was able to identify five of these first ten descending series items they continued with the 60 msec. exposure duration for the remaining perceptual identification test items. If they identified less than five of the first ten, the procedure was aborted and the 90 msec. exposure duration was employed. For this exposure duration, the first ten fillers were presented in descending series from 200 msec. to 90 msec. with the remaining test items presented at 90 msec. One subject was excluded from the study due to an inability to report any of the items presented at the 90 msec exposure duration.

Following the perceptual identification task, subjects completed a two-item forced choice recognition test. Subjects were given a sheet of paper with 20 word pairs. One member of each pair was a studied word and one and nonstudied word. Subjects were given the following instructions: "This is a test to see how well you remember the word you studied today. One word in each pair is a word you studied and one is one you did not see today. Circle the one you recognize. If you are uncertain, make a guess. Remember only one word in each pair is one you studied today."

This recognition test completed the main part of the experiment. Three additional measures were obtained. The first was the Shopping List Test. Subjects were given the following instructions: "We are interested in 'everyday memory'-- the memory tasks people do naturally. We have

been trying to put together an "average person's" shopping list. We need to figure out what grocery store, department store, and drug store items people buy most often. To help us develop this list could you please tell me 15 things you most oftee buy or a friend or relative buys for you at the store." Responses were written verbatim. If subjects provided a general category, for example "meat", they were asked to give a specific item from the category, for example "hamburger". Only specific items were recorded. After approximately 20 minute filled delay interval, subjects were asked to give the exact shopping list they provided earlier. Subjects were prompted to give 15 items even if this required guessing. Responses were recorded verbatim.

During the delay interval the remaining tests were administered. The WAIS-R Vocabulary Subtest was administered in the standard manner (Wechsler, 1981). Controlled Oral Word Association Test (Benton, Hamsher, Varney, and Spreen, 1983; Lezak, 1983) was then administered. Subjects were given a letter and asked to say as many words as they could that begin with that letter in one minute. The letters F, A, and S were used in all subjects. Responses were recorded verbatim. Subjects were also asked to name as many kinds of animals as they could in one minute. Again, responses were recorded verbatim. The entire experimental session took approximately two hours.

Item Recognition Experiment

Subjects

Younger adults. Fifteen University of Florida undergraduate students (6 females and 9 males) were each paid $10.00 to participate in the experiment. Each subject was right handed and reported English as their native language. Mean age was 21.5 years with a range of 19 to 26 years. Mean years of education and WAIS-R Vocabulary scaled scores were 14.4 and 12.2 respectively.

Older adults. Fifteen community dwelling older adults (7 males and 8 females) were each paid $10.00 for their participation in the study. They were recruited through the same newspaper advertisement as subjects in the Item Recognition Experiment and met the same criteria. Mean age was 67.2 years with a range of 61 to 77 years. The older adults' mean years of education and mean WAIS-R Vocabulary scaled score were not significantly different from that of the Younger Adults (14.0 and 13.7 respectively). Table 3-3 summarizes subject variables for this experiment.

Design

The experimental design was identical to the Lexical Decision Experiment. The same prime-target word pairs conditions and SOA conditions were used. See Table 3-4 for a Lexical Decision sample study-test list.

Materials

The same set of 360 word pairs were used in this experiment. In the test lists, however, extra word pairs replaced six word-nonwords in target positions.

Table 3-3. Means Years of Age and Education, WAIS-R Vocabulary Scale Score, and Verbal Fluency Score for Younger and Older Subjects in Item Recognition Experiment.

Group	Age	Education	Vocabulary	Fluency
Younger	21.4 (19-26)	14.4 (13-18)	12.2 (9-16)	46.5 (36-61)
Older	67.2 (61-77)	14.1 (12-18)	13.6 (9-18)	44.8 (30-53)

Note: Verbal Fluency Score is the sum of correct responses generated in 60 seconds for each F, A, and S letter stimulus.

Procedure

Subjects performed the yes/no practice trial and study practice trial in an identical fashion as subjects in the Lexical Decision Experiment. At the end of the study list the following instructions were given: "Now there will be a test list. In the center of the screen you will see a first word followed immediately by a second word. If this second word was in the list you just studied, respond 'yes' by hitting the 'yes' key. Respond 'no', by hitting the 'no' key, if the second word was not in the list. You do not have to decide whether the first and second word were

Table 3-4. Sample Study-Test Trial for Item Recognition Priming Paradigm.

Study Pairs (n=10)		Prime-Target (Test) Pairs (n=18)		
METAL	BENCH	METAL	LATCH	(N)
CANNON	ASSAULT	PARLOUR	BEACH	(F)
HATE	LOVE	OPERA	VIOLIN	(2)
OPERA	VIOLIN	SWEET	SOUR	(N)
PRISON	BLADE	ATTEMPT	LONELY	(4)
BREAD	BUTTER	TABLE	CHAIR	(3)
CAPTAIN	LONELY	INVENT	TORTURE	(4)
VICIOUS	TORTURE	BARK	VICIOUS	(F)
PARLOUR	CHAIR	BREAD	BUTTER	(1)
SPORT	BEACH	FAME	PRISON	(F)
		KNIFE	BLADE	(3)
		MONDAY	EVENT	(N)
		HATE	LOVE	(1)
		CANNON	ASSAULT	(2)
		NEEDLE	THREAD	(N)
		SPORT	TIME	(N)
		NOBLE	CAPTAIN	(F)
		GRIN	BENCH	(N)

Note: 1=Studied Old Associations, 2=New Associations, 3=Non-Studied Old Associations, 4=Unprimed, F=Fillers,and N=No responses.

studied together, only whether the second word was in the list at all. Respond 'yes' or 'no' as quickly and accurately as you can. Remember you only have to respond to

the second word and you have to decide if that word was in the study list. After we go through this practice test list you will see what I mean. Rest your fingers on the 'yes' and 'no' keys to be ready to respond. Ready?"

Subjects performed the practice test list and then proceeded on with the experimental procedure as as described above. Thus, the only differences between the Item Recognition Experiment and the Lexical Decision Experiment were the use of additional fillers place of nonwords in the test list, and the decision which the subject made regarding the target word.

CHAPTER FOUR
RESULTS

Lexical Decision Experiment

Priming Paradigm

Outlier observations were defined as reaction times exceeding three standard deviations from the overall group mean reaction time. Responses below 200 msec. were also discarded. Reactions times for correct "yes" responses only were included in main analyses. Error rates were quite low, averaging 1 to 6 percent. Mean reaction times for each Priming Condition at short and long SOA were calculated for each subject. Group means of these subject means are presented in Table 4-1.

Subject mean reaction times were submitted to a 2 (Age) X 4 (Priming Condition) X SOA (2) analysis of variance (ANOVA). Main effects were obtained for Age, $F(1,28) = 12.19$, $p < .0019$, Priming Condition, $F(3,84) = 55.82$, $p < .0001$, and SOA, $F(1,28) = 8.30$, $p < .0075$. Mean reaction times for younger and older adults were 581 msec. and 699 msec. respectively.

The significant main effect of SOA reflects the faster response times exhibited by all subjects in the long SOA condition as compared to the short SOA. The Age X SOA

interaction approached significance, $F(1,28) = 2.82$, $p = .10$. As Table 4-1 indicates, older adults showed a strong

Table 4-1. Mean Reaction Times (in milliseconds) for Correct "Yes" Lexical Decisions.

Group	SOA	Priming Condition			
		Studied Old Assoc.	New Assoc.	NonStud. Old Assoc.	Unprimed
Younger Adults	150	(n=296) 535 [9] {1%}	(n=295) 596 [11] {2%}	(n=289) 600 [10] {4%}	(n=296) 613 [10] {1%}
	900	(n=297) 490 [10] {1%}	(n=293) 573 [13] {2%}	(n=291) 613 [11] {3%}	(n=292) 624 [11] {3%}
Older Adults	150	(n=297) 671 [10] {1%}	(n=294) 736 [10] {2%}	(n=293) 709 [9] {2%}	(n=292) 762 [10] {3%}
	900	(n=296) 606 [11] {1%}	(n=297) 678 [11] {1%}	(n=283) 689 [11] {6%}	(n=290) 738 [10] {3%}

Note: Number of observations is in parentheses, standard error is in brackets; percent error (including outliers) is in braces.

benefit (a reduction in reaction times) in the long SOA condition over the short SOA condition, by an average of 42

msec. Younger adults exhibited a smaller advantage (11 msec), most likely due to younger adults' generally fast reaction times (leaving less room for an advantage to be realized).

Priming effect was obtained by subtracting reaction time for a primed condition from the unprimed condition. Table 4-2 presents the priming effects for younger and older adults at the two SOA conditions. As the overall ANOVA yielded a significant main effect of Priming Condition and interaction between SOA and Priming Condition, $F(3,84) = 9.49$, $p < .0001$, as well as an interaction between Age and Priming Condition which was marginally significant, $F(3,28)=2.03$, $p=.10$, planned comparisons of each primed condition with the unprimed condition were carried out at each SOA.

<u>Priming of studied old associations</u>. In the Studied Old Associations condition, at the short SOA, younger adults showed facilitation of 78 msec., $F(1,28) = 20.22$, $p = .0003$, and older adults showed facilitation of 91 msec., $F(1,28) = 27.68$, $p < .0001$. At the long SOA, larger priming effects were obtained with this priming condition for younger, $F(1,28) = 91.32$, $p < .0001$, and older adults, $F(1,28) = 10.82$, $p = .003$. Younger adults showed a 133 msec. facilitation and older adults showed a nearly identical 132 msec. facilitation. Priming for these old associations was confirmed at the individual level as well. Fourteen of 15 younger subjects and 12 of 15 older subjects

Table 4-2. Priming Effects (in milliseconds) for Young And Older Adults in Lexical Decision Experiment.

Group	SOA	Primed Condition		
		Studied Old Assoc.	New Assoc.	NonStudied Old Assoc.
Younger Adults	150	78* (11)	17 (10)	13 (15)
	900	133* (9)	50* (16)	10 (9)
Older Adults	150	91* (22)	24 (18)	53* (18)
	900	132* (18)	60* (14)	49* (17)

Note: Priming effect is the difference in reaction time between each primed pairtype condition and the unprimed pairtype condition. Standard error is in parentheses. An asterisk (*) indicates $p < .005$.

showed facilitation at the short SOA, and all subjects showed facilitation at the long SOA. Thus, the priming of old associations effect was quite robust, occurring in both groups at both short and long SOA.

Priming of newly learned associations. In contrast, priming in the New Associations condition occurred only at the long SOA. Younger adults showed 17 msec facilitation in this condition at the short SOA, but this was not significant ($F < 1$); older adults' priming effect was slightly larger, but still non significant, $F(1,28) = 2.95$,

p = .10. At the long SOA, younger adults showed 50 msec. facilitation, $F(1,28) = 10.82$, $p = .003$, and older adults showed 60 msec facilitation, $F(1,28) = 15.76$, $p = .0007$. Examination of the priming effect at the individual level, revealed that 12 of 15 younger subjects and 13 of 15 older subjects showed facilitation at the long SOA. Thus, younger and older adults exhibited similar pattern of priming for newly learned associations, with significant faciliation of reaction time occurring only at the long SOA.

Priming of nonstudied old associations. An interesting difference between older and younger adults is seen in the Non-Studied Old Associations condition, however. Older adults showed priming in this condition at both short SOA, $F(1,28) = 9.61$, $p = .005$, and long SOA, $F(1,28) = 12.82$, $p = .0016$, while younger adults did not ($F < 1$). This difference is particularly striking at the individual level. In the short and long SOA conditions only half of the younger subjects exhibit facilitation; however, all of the older subjects show priming in the short SOA condition and 11 of 15 show priming at the long SOA condition. This is a very interesting difference as it suggests that pre-existing semantic relationships between words were more influential in older adults' processing of prime-target pairs than in younger adults.

The analyses, then, reveal that (1) older and younger adults showed equivalent priming for old associations that were recently studied; (2) this priming for old associations

occurred at both short and long SOA, although the priming effect was larger in the long SOA condition; (3) older and younger adults showed priming of newly learned associations at long SOA but not at short SOA; (4) while younger adults did not show priming for old associations when the target had been previously studied with an unrelated word, older adults did; (5) this semantic priming effect in older adults occurs at both short and long SOA.

Cued Recall

Comparisons of percent correct responses on the cued recall test for older and younger adults are presented in Table 4-3. Subject responses consisting of exact target items or derivations of target items were accepted (eg. crackers for cracker) as correct responses.

Table 4-3. Mean Percent Correct for Related and Unrelated Pairs in the Cued Recall Task.

Group	Pairtype		Total
	Old Assoc.	New Assoc.	
Younger Adults	88% (10)	70% (17)	79% (13)
Older Adults	83% (12)	38% (22)	60% (16)

Note: Standard deviations are in parentheses.

It is apparent that older adults performed best when the pairs were old associaitons, with a mean percent correct of 83% compared to younger adults mean correct of 88% For new associations, however, older adults recall half the

number that younger adults recall (38% and 70% respectively). The number of correct cued recall responses for old and new associations was submitted to a 2 (Age) X 2 (Pairtype) repeated measures ANOVA. Significant main effects were obtained for Age, $F(1,28) = 12.06$, $p < .002$, and Pairtype, $F(1,28) = 154.58$, $p < .0001$. Reflecting older adults good recall of old associations and poor recall of new associations, the Age by Pairtype interaction was significant, $F(1,28) = 21.56$, $p = .0002$. Newman-Keuls post hoc means comparisons for total cued recall, cued recall of old associations and new associations yielded significant differences ($p < .05$) between older and younger adults for new associations and overall cued recall performance. The difference between older and younger adults' recall of old associations was not significant, however. When interpreted in the context of the reaction time data, these results suggest that older adults showed normal implicit memory for newly associated word pairs, although their explicit memory for the same pairs was well below that of younger controls.

Item Recognition Experiment

Priming Paradigm

Outlier observations were defined as reaction times exceeding three standard deviations from the overall group mean reaction time. Responses below 200 msec. were also discarded. Reaction times for correct "yes" responses only were included in main analyses. Error rates varied with Priming Condition and with Age, averaging 5 to 38%.

Error rate analyses will be presented in detail below. Mean reaction times for each Priming Condition at short and long SOA were calculated for each subject. Group means of these subject means are presented in Table 4-4.

Table 4-4. Mean Reaction times for Younger and Older Subjects for Correct "yes" Responses in Item Recognition Priming Task.

Group	SOA	Priming Condition: Studied Old Assoc.	New Assoc.	NonStud. Old Assoc.	Unprimed
Younger Adults	150	(n=280) 629 [18] {6%}	(n=285) 683 [15] {5%}	(n=237) 778 [17] {21%}	(n=256) 779 [15] {15%}
	900	(n=275) 536 [14] {8%}	(n=282) 609 [16] {6%}	(n=244) 745 [20] {18%}	(n=266) 732 [14] {11%}
Older Adults	150	(n=265) 834 [20] {12%}	(n=277) 859 [17] {8%}	(n=199) 978 [25] {34%}	(n=237) 970 [21] {21%}
	900	(n=262) 775 [20] {13%}	(n=260) 866 [22] {13%}	(n=187) 981 [29] {38%}	(n=220) 960 [22] {27%}

Note: Number of observations is in parentheses, standard error is in brackets; percent error (including outliers) is in braces.

Subject mean reaction times were submitted to a 2 (Age) X 2 (SOA) X 4 (Priming Condition) repeated measures ANOVA. Older adults' mean reaction times were significantly longer than younger adults' (903.42 msec and 686.48 msec respectively), $F(1,28) = 18.17$, $p = .0004$. Significant main effects were also obtained for SOA, $F(1,28) = 8.05$, $p = .008$, and Pairtype, $F(3,84) = 85.85$, $p < .00001$.

Stimulus onset asynchrony. The effect of SOA on reaction time is complex and must be considered in light of the significant interaction between SOA and Priming Condition, $F(3,84) = 3.18$, $p = .027$, and the marginally significant interaction between SOA and Age, $F(3,84) = 3.07$, $p = .087$. Consulting Table 4-4, it is apparent that younger adults respond more quickly under the long SOA condition in all Priming Conditions. This facilitation with long SOA may reflect a benefit obtained when the longer SOA provided younger adults with time to initiate a search of memory in response to the prime word. Having initiated this search and done so sucessfully (finding the correct target item in memory), younger adults were able to evaluate the target item more quickly. Examining the older adults response times with respect to SOA suggests process differences. Older adults show the same benefit under the long SOA condition when the prime-target pairs are old associations that were studied. However, when the pairs are newly learned, this benefit is not seen, nor is it seen when the prime-target pairs are old associations that were not

studied as pairs. The effect of long SOA on the priming of new associations may be to allow older adults time to initiate a search of memory. However, unlike younger adults, this search is not successful, and, in fact, appears to impair their ability to evaluate the target as a previously presented word relative to the short SOA condition. The short SOA condition may prevent this search process from being engaged.

Priming of old associations. Priming effect is defined as the difference in reaction time between a primed condition and the unprimed condition. These differences are presented for each group at each SOA in Table 4-5. Planned comparisons of reaction times for each primed conditions with the unprimed condition were performed for both groups at each SOA. As suggested in the analyses of SOA, strong priming effects were obtained for studied old associations at the short and long SOA for both younger and older adults (p values $< .0001$). This robust priming effect was confirmed at the individual level with 14 of 15 younger adults and 14 of 15 older subjects showing priming at the short SOA, and all subjects in both groups showing priming at the long SOA.

Priming of newly learned associations. In the analyses of priming for newly learned associations, both groups show priming effects at both SOA (p values $< .0001$). Examining Table 4-5, the priming effects obtained for newly learned associations suggested that younger adults show larger

Table 4-5. Priming Effect for Younger and Older Subjects in Item Recognition Experiment.

Group	SOA	Primed Condition		
		Studied Old Assoc.	New Assoc.	NonStudied Old Assoc.
Younger Adults	150	149* (19)	96* (12)	1 (13)
	900	196* (20)	123* (14)	-13 (15)
Older Adults	150	137* (22)	111* (22)	-8 (30)
	900	185* (31)	94* (23)	-21 (31)

Note: Priming effect is calculated by subtracting reaction time for a primed condition from the unprimed condition. Asterisks (*) indicate significance at the $p < .0001$ level. condition. Standard errors are in parentheses.

priming effects under the long SOA condition compared with the short SOA condition (123 msec. and 96 msec. respectively). However, older adults show the opposite pattern: larger priming effects are obtained in the short SOA condition than in the long SOA condition (111 msec. and 94 msec. respectively). Although these Age by SOA differences are in the direction indicated by the analyses of reaction time and SOA discussed above, they do not reach significance when analyzed as priming effect ($p = .21$). Thus, older adults exhibited priming for newly learned

associations at both SOA's, but the differences in the size of the priming effect in the two SOA conditions were not large enough to reach significance.

At the individual level, all younger subjects exhibited priming for new associations at both the short and long SOA. Similarly 14 or 15 older adults showed priming at the short SOA. Consistent with other subtle differences seen at the long SOA, only 12 of 15 older adults showed priming at the long SOA.

Priming of nonstudied old associations. As can be seen in Table 4-5, the Non-Studied Old Association condition did not produce facilitate in reaction time for either group, $F < 1$. Thus, neither younger or older adults showed priming between old associations when the target item had been previously studied with an unrelated word. The absence of a priming effect in this condition does not reflect a simple failure of the prime stimulus to facilitate processing of the target. Instead, a considerable disruption of processing is evident in the large variance and high error rate (Table 4-4). The variance and error rate are considerably higher in the Non-Studied Old Association condition than that obtained in the Unprimed condition. (These two conditions are comparable in that both have prime words that were not studied and target words that were studied; the only difference between the two is that one contains prime target pairs that are related and one the other condition does not). Thus, the conflict between old

and new associations inherent in this condition resulted in disruption of processing beyond that attributable to being not primed. This disruption is confirmed at the individual level with only half the subjects in each group showing priming at either SOA.

Item Recognition Accuracy

Table 4-6. presents the proportion correct for younger and older adults item recognition responses. After arcsin transformation (Winer, 1971), proportion correct was submitted to a 2 (Age) X 2 (SOA) X 4 (Priming Condition) repeated measures ANOVA. Significant main effects were obtained for Age, $F(1,28) = 17.7$, $p = .0005$, SOA, $F(1.28) = 5.1$, $p = .03$, and Priming Condition, $F(3,84) = 60.7$, $p < .0001$. There was no significant interaction between Age and SOA or SOA and Priming Condition. However, a significant Age by Priming Condition interaction was obtained, $F(3,84) =2.7$, $p = 05$. Although a significant three-way interaction was not obtained, interesting differences in accuracy were apparent when examining simple effects for each Priming Condition at each SOA.

Older adults' accuracy was equivalent to younger adults' for the Studied Old Association condition at short SOA ($F < 1$), but the differences between the two groups approached significance at the long SOA, $F(1,28) = 2.9$, $p = .10$. As anticipated, age-related differences in accuracy were more apparent for targets of newly learned associates.

At the long SOA significant age differences in accuracy were obtained, $F(1,28) = 4.69$, $p = .04$. At the short SOA,

Table 4-6. Item Recognition Accuracy for Younger and Older Adults.

Group	SOA	Priming Condition			
		Studied Old Assoc.	New Assoc.	NonStud. Old Assoc.	Unprimed
Younger Adults	150	.94 (.02)	.96 (.02)	.81 (.03)	.90 (.02)
	900	.93 (.02)	.94 (.01)	.83 (.03)	.91 (.02)
Older Adults	150	.90 (.03)	.92 (.03)	.66 (.05)	.81 (.03)
	900	.88 (.02)	.88 (.03)	.65 (.04)	.76 (.02)

Note: Item recognition accuracy is expressed as proportion correct; standard error is in parentheses.

however, this difference was only marginally significant, $F(1,28) = 3.03$, $p = .09$. Thus, in these two priming conditions, the majority of older adults errors occurred under the long SOA conditions. The difference in older adults' accuracy for New Associations at the short and long SOA is particularly apparent in Table 4-4, as the error rates reported in this table include outlier responses as well as incorrect responses. When these outlier responses are included, younger adults have an average error rate of 5% in the short SOA condition and 6% in the long SOA

condition. In marked contrast, older adults have an average error rate of 8% in the short SOA condition and 13% in the long SOA condition. This difference in older adults' error rates in the short and long SOA is not as striking in the other primed pairtypes or in the unprimed condition.

Dramatic differences in accuracy were obtained in the Non-Studied Old Associations condition. While both groups made more errors in this condition, older adults' error rate was significantly higher than the younger adults for both short, $F(1,28) = 7.91$, $p = .009$, and long SOA, $F(1,28) = 18.75$, $p = .0004$. Older adults were also much less likely than younger adults to correctly identify a previously seen item in the unprimed condition (when the prime and target were neither related or studied as pairs). This was evident in both short SOA, $F(1,28) = 9.34$, $p = .005$, and long SOA, $F(1,28) = 25.04$, $p = .0001$.

Cued Recall

Table 4-7 presents comparisons of percent correct responses on the cued recall test for older and younger adults. Subjects responses consisting of exact target items or derivations of target items (e.g., crackers for cracker) were accepted as correct responses.

It is apparent that older adults performed best when the pairs were semantically related with a mean correct of 82% compared to younger adults mean correct of 92%. For the Unrelated pairs, however, older adults recalled half the

number that younger adults recalled (32% and 66% respectively). The number of correct cued recall responses

Table 4-7. Mean Percent Correct for Related and Unrelated Pairs in the Cued Recall Task.

Group	Pairtype		Total
	Related	Unrelated	
Younger Adults	92% (7)	66% (20)	78% (13)
Older Adults	82% (8)	32% (14)	58% (10)

Note: Standard deviations are in parentheses.

for related and unrelated pairs was submitted to a 2 (Age) X 2 (Pairtype) repeated measures ANOVA. Significant main effects were obtained for Age, $F(1,28) = 26.10$, $p < .0001$, and Pairtype, $F(1,28) = 220.76$, $p < .0001$. Reflecting older adults good recall of related pairs and poor recall of unrelated pairs, the Age by Pairtype interaction was significant, $F(1,28) = 21.56$, $p = .0002$. Newman-Keuls post hoc means comparisons for total cued recall, cued recall of related and unrelated pairs yielded significant differences ($p=.05$) between older and younger adults for both pairtypes and overall cued recall performance. Thus, even though older adults remembered 16 of 20 related cued recall items, younger adults performed significantly better.

Comparisons of Item Recognition and Lexical Decision

Analyses for comparing lexical decision and item recognition were performed by submitting priming effects for each of the three primed conditions to a 2 (Age) X 2 (Experiment) analysis of variance. SOA was included in the analysis for priming of New Associations only, since the age by SOA interaction was marginally significant in this condition only.

Priming for Old Associations

As anticipated, priming of old, well-learned associations is a robust phenomenon. Given a brief period of study, older and younger adults in both lexical decision and item recognition experiments demonstrated large priming effects for these semantically related word pairs. Table 4-8 presents a comparison of the priming effects obtained for this Studied Old Associations condition in the two experiments. Collapsing across SOA, priming effects were larger in the item recognition task than in the lexical decision task $F(1,116) = 16.60$, $p = .0002$, with no

Table 4-8. Priming Effects for Studied Old Associations in Lexical Decision and Item Recognition Experiments.

Group	Experiment	
	Lexical Decision	Item Recognition
Younger Adults	105 (9)	173 (14)
Older Adults	111 (14)	161 (19)

Note: Standard errors are in parentheses.

significant interaction between Age and Paradigm Type ($F < 1$). Newman-Keuls post hoc means comparisons confirmed this lack of interaction by indicating that both younger and older adults showed larger priming effects in the item recognition experiment ($p < .05$).

Priming for New Associations

Supporting the hypothesis that older adults can demonstrate implicit memory for newly formed associations, both older and younger adults showed priming between previously unrelated word pairs that had been studied experimentally. Comparing the two priming tasks (Table 4-9), however, age differences in processing are suggested.

At the short and long SOA, both younger and older adults show larger priming effects in the Item Recognition experiment than Lexical Decision (p values $< .05$). As mentioned above, the facilitation observed for newly associated word pairs at the short SOA in the Lexical Decision task is not significant in either group. When the time between the prime and target is lengthened in the long SOA condition, younger adults still show larger priming effects in the Item Recognition task, ($p < .05$) while older adults do not. Older adults not only respond more slowly in this condition, but they also commit more errors. Thus, in

Table 4-9. Priming effects for Newly Learned Associations in Lexical Decision and Item Recognition Experiments.

Group	SOA	Experiment	
		Lexical Decision	Item Recognition
Younger Adults	150	17 (10)	96 (12)
	900	50 (16)	123 (14)
Older Adults	150	25 (18)	111 (20)
	900	60 (14)	94 (23)

Note: Standard errors are in parentheses.

the demonstration of implicit memory for new associations, older adults perform like younger adults in the Lexical Decision experiment, when a conscious decision regarding the status of a target item in memory is not required. However, when a memory decision is required and older adults are given more time to process the prime word (as in the long SOA condition of the Item Recognition experiment), subtle but consistent age differences are found in the form of longer reaction times and increased error rates.

Priming for Nonstudied Old Associations

Clear age and paradigm differences were apparent when examing the priming effects for old associations that were not studied (Table 4-10). SOA did not differentially affect priming effect in this condition so comparisons were performed collapsing across this variable. In contrast to

performed collapsing across this variable. In contrast to the other primed conditions, larger priming effects were obtained in the Lexical Decision task than in the Item Recognition task, $F(1,116) = 9.32$, $p = .003$. As Table 4-10 shows, older and younger adults perform differently in the Lexical Decision task and similarly in the Item Recognition task. This interaction between Age and Paradigm Type approaches significance, $F(1,116) = 2.98$, $p = .08$. Newman-Keuls post hoc means comparisons indicate that younger

Table 4-10. Priming Effects for Non-Studied Old Associations in Lexical Decision and Item Recognition Experiments.

Group	Experiment	
	Lexical Decision	Item Recognition
Younger Adults	12 (14)	- 6 (14)
Older Adults	51 (18)	- 14 (30)

Note: Standard errors are in parentheses.

adults fail to demonstrate priming in either experiment ($p > .05$). Older adults clearly show priming for these old associations in the Lexical Decision task but not in the Item Recognition task ($p < .05$). Thus, the processing differences in the item recognition and lexical decision tasks are highlighted when comparing older adults performance in this priming condition.

Implicit and Explicit Memory for Single Words

Lexical Decision Experiment

Implicit memory for single words was tested via perceptual identification. The probability of correctly identifying previously studied words versus nonstudied words in the perceptual identification task is presented in Table 4-11. Arcsin transformations of these probabilities were submitted to a 2 (Age) X 2 (Item Status) ANOVA. A significant main effect for Item Status (studied versus nonstudied) was obtained, $F(1,28) = 49.74$, $p < .0001$, indicating that studied words were identified more frequently than distractors. The main effect for Age and the interaction of Age and Item Status were not significant ($F < 1$). Thus, both older and younger subjects demonstrated implicit memory for previously studied items.

In contrast, age differences were found in the explicit recognition test, $F(1,28) = 6.00$, $p = .02$. Younger adults recognized an average of 95% (+/-3%) compared to 88% (+/-9%). Thus, while older adults explicitly recognized fewer studied words than younger adults in the recognition test, the two groups identified an equivalent number of studied words in the implicit task.

Table 4-11. Probability of Perceptual Identification as of Function of Prior Study for Younger and Older Subjects.

Group	Item Status	
	Studied	Not Studied
Younger Adults	.65 (.19)	.42 (.23)
Older Adults	.60 (.24)	.32 (.21)

Note: Standard deviations are in parentheses.

Item Recognition Experiment

As in the Lexical Decision experiment, priming or implicit memory for single words that were studied was determined by comparing the number of studied and nonstudied words identified in the perceptual identification task. Probabilities of perceptual identification of targets and distractors are presented in Table 4-12. Analysis of these probabilities revealed a significant effect of prior study, $F(1,28) = 59.00$, $p < .0001$. Main effect for Age approached significance, $F(1,28) = 3.73$, $p = .06$, owing to older adults' identifying more items overall than younger adults. This most likely reflects the use of longer exposure durations (60 msec. or 90 msec.) in older adults and the variability in the procedure with this group. More importantly, however, the interaction between Age and Item Status (studied versus not studied) was not significant ($F <$

1). Thus, both older and younger adults identified more studied words than not studied words.

Table 4-12. Probability of Perceptual Identification as of Function of Prior Study for Younger and Older Subjects.

Group	Item Status	
	Studied	Not Studied
Younger Adults	.58 (.24)	.34 (.22)
Older Adults	.73 (.17)	.46 (.15)

Note: Standard deviations are in parentheses.

Due to a ceiling effect, significant age differences were not found on explicit recognition testing. Younger adults correctly recognized 93% and older adults recognized 90%. This ceiling effect prevents meaningful conclusions regarding a dissociation between implicit and explicit memory for single words in older adults.

Shopping List Test

The Shopping List Test was included as a everyday memory measure of episodic and semantic memory (West and ?, 198?). Subjects are required to selectively retrieve a subset of information from semantic memory that was retrieved in a recent episode. The dependent variable was the number of shopping list items retrieved by the subject which were items they reported eariler as their most

frequent shopping list items. Total possible correct was 15 items. Mean correct shopping list items did not vary with across the two experiments, thus the data were collapsed with respect to this variable. Younger adults retrieved an average of 14.03 (+/- .65) items while older adults retrieved an average of 12.97 (+/- .80) items. This difference was significant at the p=.05 level. Older adults retrieved fewer shopping list items than younger adults eventhough these items had been originally generated from their own familiar shopping list.

CHAPTER FIVE
DISCUSSION

As anticipated, a dissociation between implicit and explicit memory was demonstrated in older adults' performance. Both younger and older adults showed priming for single words, while older adults recognized fewer single words than younger adults. Since priming for single words has been reported by other investigators (Light and Singh, 1987; Light, Singh, and Capps, 1986; Moscovitch, 1982), the present discussion will focus primarily on the associative priming effects and their theoretical implications.

Priming effects for newly associated words will be discussed first; the specificity hypothesis will be advanced as a conceptual framework for explaining the present results and for directing future investigations of implicit and explicit memory. Next, the priming effects for old associations will be discussed. The interpretation of these results will focus on the influence of overlearned semantic relationships on the processing of novel information.

Priming for New Associations

Lexical Decision

Age differences in priming of newly formed associations were not found using a lexical decision task. Both older

and younger adults exhibited convincing and equivalent priming effects for recently learned word pairs under the long SOA condition. Facilitation was also obtained at the short SOA, but this effect did not reach significance in either group.

The sensitivity of priming for new associations to SOA, suggests that, although an association was formed, it was not activated in a passive automatic fashion. Instead, the long time lag between the presentation of the prime and the presentation of the target allowed both older and younger adults to intentionally anticipate the target item. Despite the fact that the decision itself was not based on the target item's status in recent memory (but rather on the target item's status in the lexicon), both groups appeared to use an intentional search of recently formed associations to improve their response times.

Previous studies of associative priming in a lexical decision task have debated whether automatic facilitation occurs for new associations. While McKoon and Ratcliff (1986) obtained priming of newly learned associations at SOA as short as 150 msec., suggesting that new associations can be automatically activated, many others have not (den Heyer, 1986; Neely and Durgunoglu, 1985; Durgunoglu and Neely, 1987). Durgunoglu and Neely (1987) methodically examined a variety of factors which might influence priming for new associations at a short SOA (e.g., intermixing short and long SOA within a block of priming trials, including

nonwords in the study lists, excluding semantically related words from the priming trials). They concluded that, in a lexical decision task, automatic priming for new associations occurs only under highly circumscribed conditions. Thus, the absence of priming at the short SOA found in the present experiment is not unexpected. More importantly, if a short SOA is assumed to promote automatic processing, it is clear that this manipulation did not provide a specific advantage for older adults. Thus, the claim that older adults' intact implicit memory performance is the result of the automatic, unaware or passive activation of an underlying memory representation must be rejected as overly simplistic.

More interesting then, is the use of strategies by both older and younger adults to facilitate lexical decisions. Durgunoglu and Neely (1987) proposed that when a lexical decision task contains an item from an immediately preceding paired associate learning task, subjects recognize that the episodic information is useful in making lexical decisions. When a prime is presented, recently formed associations allow subjects to retrieve the representation of the studied word pair, and thus prepared themselves to respond "word" if the target is a match. If the presented target is a word that does not match the representation retrieved by the subject, the response is slower. "Nonword" responses are slower still. Priming of lexical decisions for newly learned associations, then, most likely reflects a

strategic process. Contrary to the hypothesized age-related decline in effortful processing, older adults appeared to use this strategy in the same manner as younger adults.

Item Recognition

In the Item Recognition experiment, both groups demonstrated priming for new associations at both short and long SOAs. Given that the item recognition task required an evaluation and explicit decision regarding the status of an item in memory, it may seem counterintuitive that priming was obtained at the short SOA (which presumably promotes automatic processing) in this task when it was not in the Lexical Decision experiment. However, close examination of the data reveals interesting age and task differences.

First, the priming obtained at short SOA in this task cannot be interpreted as automatic facilitation. Reaction times at the short SOA in both groups were quite long, indicating that processing continued for up to 700 msec. after the presentation of the target. The failure of the short SOA to restrict processing to automatic activation exemplifies the limitations in using SOA manipulations to delineate automatic and strategic processing. Particularly in more difficult tasks, automatic activation will be masked by other strategic components.

Although the SOA manipulation did not provide information regarding automatic versus strategic processing, it does reveal age differences in the process of retrieval. Younger adults' reaction times were facilitated considerably

in the long SOA condition over the short SOA condition. This benefit in the long SOA condition may reflect younger adults initiating a search of memory in response to the prime. As their search was likely to be successful they correctly anticipated the target and were able to respond more quickly. The short SOA did not allow sufficient time for this search to be initiated. In this case the prime and target most likely formed a single unit which was then evaluated regarding its familiarity as a compound cue (Ratcliff and McKoon, 1988).

Older adults, however, failed to demonstrate this benefit in the long SOA condition. Older adults still showed priming in the long SOA condition; however, they clearly did not benefit from the long SOA (relative to the short SOA) in the same manner as younger adults. In addition, older adults were significantly less accurate than younger adults in the long SOA condition, but the difference in accuracy was not significant in the short SOA condition. These findings suggest that, in the long SOA condition, older adults also initiated a search of memory in response to the prime. However, this search was less successful than it was in younger adults. Older adults were not able to efficiently and reliably identify the correct target item in memory; thus, when the target was presented, they did not realize the benefit of searching memory and anticipating a response. Their higher error rate in the

long SOA condition suggests that alternative responses may have been retrieved resulting in interference.

Under the short SOA condition, older adults were not given time to initiate a search in response to the prime. As with younger adults, the close presentation of the prime and target allowed the two words to form a single unit which was then evaluated regarding its familiarity. Older adults may have responded quickly and as accurately as younger adults for two reasons: alternative response may not have been generated in a search process; and the prime and target together form a stronger and more specific representation than either alone, decreasing the degrees of freedom in the match process.

The two previous studies of implicit memory for new associations (Rabinowitz, 1986; Howard et al., 1987) did not address the effect of SOA on reaction times. Rabinowitz did not control SOA. Howard et al., reported that half of her participants were assigned to a 150 msec SOA condition and half to a 450 msec SOA condition. They failed to find differences related to the SOA manipulation. Two factors may have conspired against finding significant SOA differences in their study. First, the between subjects manipulation of this variable may have reduced the power for detecting an effect. Second, a 450 msec SOA may not have been long enough to show an advantage in younger adults or, more likely, the lack of advantage in older adults. Third, differences in processing propositions (as in the Howard et

al. study) versus paired associates (as in the present study) may also contribute to differences in the two experiments. Future investigations examining the Howard et al. priming task with the SOA manipulation used in this experiment may help to clarify this discrepancy.

In summary, the priming effects obtained in lexical decision and item recognition, and cued recall test performance supports Hypothesis One. As the retrieval demands were varied from implicit to explicit (i.e., lexical decision priming to item recognition priming to item recognition accuracy to cued recall accuracy) the effect of age was more pronounced. Hypothesis Two was supported in the Item Recognition Experiment; age differences were apparent (in a subtle fashion with reaction time and in a more obvious fashion in accuracy) only under the long SOA condition when there was sufficient time to initiate a strategic search of memory. This hypothesis was not supported in the lexical decision task, in which older adults exhibited priming effects equivalent to younger adults at both the short and long SOA.

The Specificity Hypothesis

Although the concepts behind Hypotheses One and Two were supported (i.e., that older adults' memory performance is particularly sensitive to retrieval demands and to the requirement of strategic memory search), several issues remain unclear. First, it was proposed that older adults' intact priming effects at the short SOA would be the result

of an automatic facilitation. However, priming effects were not obtained at the short SOA in lexical decision, and the priming effects obtained at the short SOA in item recognition cannot be attributable to automatic facilitation. Thus, the importance of automaticity in older adults' implicit memory performance must be questioned.

Second, although the pattern of age differences and similarities corresponds to differences in the retrieval demands of the various tasks, this observation simply restates that some aspect of retrieval is critical in determining older adults' memory performance. Advancing beyond a simple retrieval failure explanation hinges upon indentifying factors which contribute to and interact with various retrieval conditions.

The two previous studies of associative priming in older adults used experimental procedures similar to the long SOA item recognition condition in the present experiment, and similar results were obtained (Rabinowitz, 1986; and Howard et al., 1987). Rabinowitz (1986) and Howard et al. (1987) proposed that older adults show a deficit in conscious deliberate search of memory, which is alleviated by implicit memory procedures. Howard (1987) elaborated this retrieval failure explanation, emphasizing that the process of retrieving a specific item in memory appears to be particularly vulnerable to aging.

Conceptualizations of implicit memory for new associations in mild amnestics (Schacter and Graf, 1986; and

Graf and Schacter, 1987) have focused largely on factors which differentiate this type of priming effect from implicit memory for preexisting information. This work demonstrated that a minimal level of elaborative encoding is required to elicit this type of priming effect and that individuals with severe amnesia are apparently unable to perform this minimal requirement. In addition, Graf and Schacter (1987) demonstrated that priming for new associations is unaffected by proactive and retroactive interference. These authors recognized that existing models of implicit and explicit memory developed from investigations of priming of preexisting representations are insufficient to account for implicit memory for new associations.

Acknowledging that a conclusive explanation for differences in implicit and explicit memory for new associations does not exist, Graf and Schacter (1987) offer several interesting ideas. First, they, like Howard, (1987), point out that explicit memory tests require subjects to retrieve a specific item from a representation of a specific memory event. Further, this ability is likely to be influenced by the degree to which an item can be distinguished from other items in that same event. Implicit memory instructions often do not require that an item be retrieved with reference to a specific event. They argue that under implicit memory retrieval conditions,

> ...the components of the pair representation that distinguish it from other study-list pairs and relate it to a specific experimental situation are not critical for test performance. Instead, implicit memory for new associations may depend primarily on those components of a representation that relate the two words in a pair to each other, independent of the other pairs in the study list. If, as we suggest, interference effects on explicit memory tests are attributable to a relative decrease in the distinctiveness of the representational components that distinguish one study-list pair from others, then it is not surprising that implicit memory for new associations which does not depend upon these components, is not affected by interference manipulations (Graf and Schacter, 1987, pp. 51).

Graf and Schacter's emphasis on the interaction between the memory representation and the retrieval demands of implicit and explicit memory tasks advances our understanding beyond a simple retrieval failure explanation.

The hypothesis presented in this paper draws upon the conceptual contributions of Howard (1987) and Graf and Schacter (1987) concerning the interaction between distinctiveness of the memory representation and specificity at retrieval. These views are further elaborated and extended to form a general framework for investigating this phenomenon; this framework is tentatively referred to as the specificity hypothesis. The specificity hypothesis asserts that three factors interact dynamically to determine the success of memory retrieval: specificity or distinctiveness of the memory representation, specificity of the retrieval cue, and specificity of the decision required in the task.

<u>Specificity of the memory representation</u>. Specificity or distinctiveness of the memory representation determines two aspects of retrieval: (1) the degree to which the representation can be distinguished or identified as a separate entity despite its relationships and shared attributes with other representations; and (2) the flexibility with which it can be retrieved. A highly specific representation enables access of more detailed information regarding the memory event, under a wide variety of retrieval conditions. Thus, neurologically intact young individuals can access a memory representation in a highly flexible manner (via priming, recognition, cued recall or free recall) and in sufficient detail to perform a variety of discriminations and judgments regarding its status in the context of recent experience. As Graf and Schacter (1987) point out, the importance of distinctiveness in explicit remembering has been long recognized (e.g., Moscovitch and Craik, 1976). Presumably, the degree of specificity inherent in a memory representation is largely determined by factors occurring at encoding and changes which take place when a memory representation is retrieved under various circumstances and stored again.

<u>Specificity of the retrieval cue</u>. The specificity of the retrieval cue can determine the degree to which retrieval is dependent on the specificity or distinctiveness of the memory representation. Specificity in the retrieval cue refers to the degree to which the retrieval cue emulates

the encoding stimulus. This is similar to Jacoby's (1983 a and b) and Roediger and Blaxton's (1987) match of processing concept. A processing match resulting from a highly specific retrieval cue improves performance in memory impaired individuals by reducing the degree to which the burden of retrieval is dependent on the specificity of the memory representation.

Specificity in the decision or response. The specificity required in the subjects' decision or response (as determined by the task demands) can also modulate the degree to which retrieval success is dependent on a the specificity of the memory representation. As is the case in lexical decision, a decision can be issued quickly and with a high degree of confidence if it relies on a global or general match between a the external representation of the target and the internal representation. As Graf and Schacter (1987) argue, a similarly less specific decision is required in word completion since the response is not dependent on discriminating and evaluating the representation of a word pair as a distinct item in the larger study context. Thus, the reduced decision specificity which is inherent in implicit retrieval instructions can accommodate a lower degree of specificity in the internal representation without impacting retrieval success. However, if the decision or response requires a higher degree of specificity (as in the item recognition task or other explicit retrieval tasks), a less specific

internal representation will be insufficient and result in continued search for alternatives. As a search process continues and more alternatives are generated the ability to discriminate between the alternatives is further diminished.

While the initiation of an deliberate search process is associated with poorer memory performance in older adults (and other memory impaired individuals), the specificity hypothesis proposes that the less efficient search process and its generation of interfering response alternatives is a product of a memory failure rather than a cause. That is, older adults in the present experiment initiated an inefficient search only in the long SOA item recognition condition as a result of (1) the low degree of specificity originally encoded in the memory representation, (2) the low degree of specificity inherent in the retrieval cue, and (3) the high degree of specificity required in the decision. These conditions resulted in older adults' continued search and evaluation of recent memory for sufficient information to yield a correct response.

The Specificity Hypothesis, Aging, and Memory

In the present experiment, the specificity hypothesis is proposed to account for the data in the following manner. Younger adults form memory representations which are highly specific, containing components corresponding to the restricted context of the studied word pair as well as the larger context of the study list, experiment, etc. This high degree of specificity encoded into the memory

representation allows for a corresponding high degree of specificity in retrieval. In the item recognition task at the long SOA, younger adults can initiate a search in response to the prime and identify the specific target in memory, thereby correctly anticipating the target item before it is presented to the screen. Additionally, the memory representation can be retrieved under a wide variety of retrieval conditions (lexical decision, item recognition, cued recall).

In contrast, older adults encode in a general, nondistinctive manner (Rabinowitz and Ackerman, 1982). This lower degree of specificity may result from a variety of encoding deficiencies, irrelevant associations which are generated to a stimulus, or a failure to "attach" components which provide more precise contextual cues. The nondistinctive representation limits the amount of information available for evaluating the item status as a previously studied item. Thus, the retrieval conditions which will allow access to a less specific representation are limited.

The interaction of the specificity inherent in retrieval cues with the specificity of the memory representation is well demonstrated in the short and long SOA conditions in both priming tasks and in the cued recall task. In the short SOA condition, the prime and target are presented so closely in time that they form a single compound cue which is more specific (more similar to the

initial encoding event). Under the short SOA condition older adults were more accurate than in the long SOA condition because the prime and target together form a more specific retrieval cue than the prime alone, thereby reducing the degree to which the older adults must rely on the specificity of their internal representation. In the long SOA condition, the prime was presented alone with the target following 900 msec later. Thus, an increase in retrieval cue specificity occurred only after a significant amount of search time has elapsed. Since older adults' memory representations are less specific than younger adults, this search time was only advantageous to younger adults. Older adults showed a much clearer disadvantage in the cued recall test when the retrieval cue consisted of only the left-hand member of the word pair. In this case, retrieval was entirely dependent upon the specificity or distinctiveness of the memory representation. Thus, a more specific retrieval cue can modulate the deleterious effect of a insufficiently specific memory representation.

Comparing lexical decision and item recognition performance at the long SOA, demonstrates that the specificity of encoding interacts with the specificity required in the decision. Differences in decision specificity are well demonstrated in the lexical decision and item recognition priming tasks. In lexical decision, a correct "word" response can be facilitated with a relatively high degree of confidence, as long as the presented target

achieves a general match with a representation in memory. However, in item recognition, a accurate response is dependent upon a more precise evaluation of the memory representation (evaluating a the memory representation as an event encountered in a specific context). The reduced specificity of an internal representation of a target item would not be expected to interfere with deciding if the target is a word or not. However, the reduced specificity would be expected to hinder the evaluation of this representation as an item which was recently presented in this particular context.

Younger adults, when afforded the time to search memory (as in the long SOA condition), are able to identify components of a representation that distinguish it as belonging to a highly specific context. Older adults, when given the same amount of time, retrieve a less distinctive representation along with its irrelevant components. If a decision regarding the item's status as a previously studied word is required, this representation will not sufficiently specific; the older adult may continue to search, generating and evaluating alternative target candidates. Thus, by the time the target is finally presented the discriminability of the representation had been further attenuated, resulting in higher error rates. The less specific response required in lexical decision would prevent older adults from continuing to generate response alternatives during the long SOA interval. Response facilitation will occur if a general

match occurs between the memory representation and the presented target item.

The strength of the specificity hypothesis lies in its emphasis on the dynamic interaction of task demands with an internal representation of a memory event. In addition, it is not limited to the experimental procedure used in the present experiment. Word completion, lexical decision, item recognition, recognition, cued recall, free recall can be conceptualized in terms of a predictable interaction between task demands and the internal memory representation.

The primary assumption in the hypothesis is that the process by which younger and older adults (or other memory impaired individuals) form a representation of a memory event differs along the dimension of specificity or distinctiveness. The view that age-related memory changes are a result of nondistinctive encoding is supported by a variety of investigators (Craik and Byrd, 1982; Rabinowitz and Ackerman, 1982; Rankin and Kausler, 1979). However, the interactive role of specificity in the memory representation could not be tested in the present experiment since encoding was not manipulated. Preliminary support can be drawn from the Howard et al. (1987) study. They reported that under brief study conditions, older adults did not exhibit priming between unrelated words in an item recognition task. However, under longer study conditions, such priming effects were obtained. The extended study time may have allowed older adults to form more distinctive representations of the

word pairs. The specificity hypothesis would predict that, in this brief study condition, older adults might have shown priming using a procedure with a less specific decision (e.g., lexical decision) or using a more specific retrieval cue (e.g., shorter SOA). Systematic manipulation of encoding and retrieval demands, decision requirements, and subject populations will aid in more clearly defining and evaluating the construct of specificity.

Priming of New Associations and the Implicit/Explicit Memory Distinction

The relationship between implicit memory for new associations and the implicit/explicit memory distinction in not straightforward; however, some conclusions can be drawn. Implicit memory for new associations is clearly different from implicit memory for single words or previously learned associations (Shimamura, 1986; Schacter and Graf, 1986; Graf and Schacter, 1987; Moscovitch et al., 1986). Elaborative encoding is required to demonstrate such priming effects using word stem completion. In addition, severely amnestic patients do not show priming for new associations, but mild to moderate amnestics and older adults do. Priming for new associations in mild amnestics, like priming for preexisting representations, requires the presentation of some of the target response at retrieval. Finally, this form of priming, in normals, is not affected by proactive or retroactive interference effects. The results obtained in the present experiment support the status of implicit memory for new associations as a different entity from priming of

preexisting representations and, as will be argued, the specificity hypothesis clarifies its status with respect to the implicit/explicit memory distinction.

Reconsidering the conclusions drawn from the implicit memory literature review, it is generally accepted that both implicit and explicit memory tasks access a single underlying memory representation. However, evidence of implicit memory for preexisting representations (i.e., repetition priming) in severe amnestics and the demonstrations of these same priming effects in normals who are prevented from utilizing explicit memory, suggests that different memory processes/systems are contributing to distinct components of the memory representation (Jacoby, 1983; Graf and Mandler, 1984). This distinction in severe amnesia is sufficiently robust that it strongly suggests a true property of the underlying neurobiological substrate.

The implicit/explicit memory distinction, as a reflection of neurobiological processes, can be conceptualized in the following manner. Processes which are not dependent on the limbic memory structures occur necessarily in response to stimulus presentation and contribute highly specific perceptual components and very basic, general semantic components. These components, which although they can be quite perceptually specific, enable retrieval under only very limited, inflexible conditions. Mishkin and colleagues have proposed that cortico-striatal

connections may support this "nonlimbic memory" (Mishkin and Petri, 1984; Mishkin, Malamut, and Bachevalier, 1984).

When the limbic memory structures and their cortical connections are intact, processes dependent on these structures contribute the components which we typically consider characteristics of explicit memory: contextually rich, distinctive, elaborate representations of the memory event. Processes which are not limbic dependent also contribute to the memory representation. At retrieval both processes may contribute to remembering to varying degrees depending on the nature of the retrieval cue and the response required.

In clinical amnesia, the dissociation between the two memory systems can be clearly demonstrated. Severe amnestics are unable to demonstrate explicit remembering in any form, and they are able to demonstrate implicit memory for stimuli that have a preexisting representation in memory (formed prior to the amnestic event). Individuals who are able to demonstrate priming of new associations (which have no pre-exiting representation) can be assumed to have an incompletely damaged limbic memory system. Memory, in all its variety of manifestations, in such an individual, will reflect the inefficiency of limbic system (and its processes), the integrity of the nonlimbic system (and its processes), and the degree of specificity provided by the retrieval cue and required in the response. New learning (including new associations) can be demonstrated because the

limbic memory system is not entirely nonfunctional; however, the inefficiency of this damaged system limits the degree of specificity that can be contributed to the memory representation, thereby limiting the conditions under which the new learning can be manifested. The nondamaged extralimbic system contributes its components normally (i.e., with the same degree of specificity); however, again the retrieval value of these components is limited.

Sufficient evidence exists to propose that older adults memory impairment relates to an incomplete disruption of the corticolimbic memory system. Postmortum studies of brains from cognitively intact elderly report selective cell loss in the hippocampus, prefrontal cortex and superior temporal gyrus (Bondareff, 1977; Bamford and Caine, 1988). Thus, older adults may demonstrate a similar pattern implicit and explicit memory performance as mild amnestics. The degree of memory impairment demonstrated by an individual (older adult or neurologically impaired patient) might be expected to interact with the factors proposed in the specificity hypothesis. Direct comparisons of mild to moderate amnestics and older adults with varying degrees of memory dysfunction may elucidate this relationship.

<u>The Specificity Hypothesis and Awareness in Remembering</u>

Finally, the specificity hypothesis has important implications for the role of awareness and the intention to remember in explicit memory. The awareness of memory or the intention to remember has often been identified as the

critical feature distinguishing implicit and explicit memory. Indeed, many studies of implicit and explicit memory manipulate only the subjects' instructions to intentionally remember (Graf, Squire, and Mandler, 1984; and Graf and Schacter, 1987). These demonstrations of memory without awareness are often quite impressive, bordering on mystifying. Schacter (1987) has criticized some current conceptualizations of the implicit/explicit memory distinction because they fail to account for the apparently commanding role of conscious awareness in remembering.

However, attributing any causative role to "intention" or "awareness" necessarily creates a homunculous which in turn becomes difficult to explain. The specificity hypothesis argues that the explicit intention to remember is not a special form of remembering. Like other memory processes, the success of explicit remembering is determined by the interaction of degree of specificity in the internal memory representation, the retrieval cue, and the decision or response that is required. Free recall retrieval conditions can be characterized as providing a low degree of specificity in the retrieval cue and the high degree of specificity required in the response. The retrieval cue typically includes a verbal referent to aspects either of the context in which the information was encoded (e.g., "tell me what you remember from the list you studied or what you did yesterday"), or of the information itself (e.g., "what did you learn about sailing?"). The response is

considered highly specific because the subjects must select items in memory from many alternatives and evaluate them regarding their appropriateness as responses for this particular context. Thus, free recall is the most vulnerable form of explicit remembering because it relies most heavily on a the existence of highly specific memory representation.

Parenthetically, it should be noted that encoding contextual features (i.e., the occurrence of an event in a specific spatial-temporal location), is not afforded higher value over other components in characterizing the specificity of a representation. While contextual information is certainly an important component to a specific memory representation, this type of information does not define the success or failure of explicit remembering. Contextual information simply represents a component of a memory representation which can increase the flexibility with which it can be retrieved. Context is often quite important in tests of explicit memory since it typically serves as the verbal label in the retrieval cue (e.g., "tell me what you remember about the story I read you a half hour ago"). A highly specific memory representation can be retrieved by variety of other retrieval cues which are equally effective (e.g., semantic associations, visual/auditory associations) and which may subsequently lead to the retrieval of information regarding the memory context. Thus, the specificity hypothesis views the

encoding of context as important, but not as the single determinant of explicit remembering.

Awareness of memory can be understood as an epiphenomen of explicit remembering. This view predicts that attributions of awareness (or certainty in remembering) will be directly related to some measure of the degree of specificity in a memory representation which is retrieved into working memory. Awareness in remembering does not appear to be a unitary, all or none phenomenon. Several aspects of memory awareness have been described, such as feeling of knowing (Nelson, Gerler, and Narens, 1984), confidence, and familiarity. The variability existent in these metamemorial factors may reflect the degree of specificity retrieved. Certainly, the more vivid and rich a memory is the more aware we are of remembering.

Priming of Studied Old Associations

The data presented here, as well as those reported by other investigators, clearly indicate that preexisting representations do influence implicit memory performance. In both lexical decision and item recognition experiments, in both older and younger adults, and in both short and long SOA conditions, priming for old associations was clearly larger than priming for newly learned associations. Prior study interacts with the existing association such that, when a prime is presented, both the recent exposure and the strength of the preexisting association contribute to a facilitation in the evaluation of the target. In addition,

very small or nonsignificant age differences are found in explicit memory (cued recall) for semantically related word pairs. Thus, the preeminence of these well-learned associations overrides differences in retrieval demands and the effects of aging.

The small age differences in cued recall performance for related and studied word pairs suggests two possibilities. First, since the association is already strongly formed pre-experimentally, older adults may be able to concentrate their inefficient elaborative encoding processes to contributing distinctive information to the memory representation of the pair, thus enabling successful explicit retrieval in the cued recall task. Alternatively, the recent activation of the preexisting associations in memory may be sufficient to allow for subsequent activation of the whole word pair as a unit at retrieval with presentation of only one member of the pair. One method of differentiating these two possibilities might have entailed asking subjects for their subjective ratings of certainty for retrieved items in the cued recall test. If older adults were relying on reactivation of a unit that was not well elaborated at encoding (i.e., lacking in specificity), then they might report their successful retrievals as guesses more often than younger adults. Unfortunately, this data was not collected.

Priming of Non-Studied Old Associations

Lexical Decision

It is evident that within the context of a new learning task, strong preexisting association alone is not necessarily sufficient to demonstrate priming effects. In lexical decision, younger adults do not exhibit priming for old associations if they were not studied as pairs. Older adults, however, showed clear priming at both short and long SOA. (For review, in this condition the prime word is a word that has not been studied, e.g., GREEN, the target word is strongly related to the prime word, e.g., GRASS; however, the target has been previously studied with an unrelated word, e.g., CITY).

While this finding supports Hypothesis Three, examining these priming effects within the context of the semantic priming literature in young normals indicates that their interpretation is not entirely straightforward. Robust semantic priming effects are typically exhibited when a lexical decision task occurs alone, that is, when it is not preceded by a learning task (Meyer and Schvaneveldt, 1976). Why, then, did the younger adults not exhibit priming for these strongly related words?

The present findings are best understood within the context of studies of strategic factors influencing semantic priming of lexical decisions. A study by Tweedy, Lapinski, and Schvaneveldt (1977) demonstrated that normal subjects are quite sensitive to variables which may be utilized to

maximize performance in a lexical decision task. They examined semantic priming of lexical decisions (in the absence of paired associate learning). They found that facilitation of lexical decision due to the semantic relationship between a prime and target varied with the characteristics of the priming list. If a high proportion of semantically related word pairs appear in a lexical decision priming list, then semantic priming is more likely to occur; if a low proportion of related pairs are used semantic priming is less likely to occur. Tweedy et al. (1977) proposed that subjects adjusted their processing of the prime word to reflect the perceived benefit of semantic relationships in facilitating their reaction times. If the frequency of semantically related word pairs was high, subjects processed the prime word semantically to facilitate processing of the target. deGroot (1984) reported that subjects can exhibit this alteration of strategy at both short and long SOA.

Durgunoglu and Neely (1987) propose that strategic factors may play an even greater role when lexical decision is preceded by paired associate learning. Indeed, several investigators examining priming in younger adults have not obtained semantic priming of lexical decisions when the related words were not recently studied (Carroll and Kirsner, 1982; Neely and Durgunoglu, 1985; Durgunoglu and Neely, 1987). Durgunoglu and Neely (1987) reviewed several studies of lexical decision priming and investigated the

conditions required to obtain semantic priming effects in a lexical decision task. They proposed that when the lexical decision task contains recently studied word pairs, subjects alter their strategy for making lexical decisions to incorporate this episodic information. The subject can respond faster if relationships established during the recent learning task are utilized rather than preexisting relationships which were not recently studied. In this case subjects perceive the previous study context as more salient to the priming task than semantic relationships alone.

In the present study, the priming task was immediately preceded by a study list and the proportion of semantically related words in the priming task was low (4 pairs of 18 pairs in each lexical decision priming list). Thus, both factors could have convinced younger adults that semantic information alone was not useful in facilitating lexical decisions. Words that were semantically related, but not recently studied would not show significant priming because probabilistically this purely semantic information is not useful in facilitating response time.

What is of great interest, then, is the finding that older adults do show priming in this condition. This suggests that older adults, unlike younger adults, were not influenced by the probabilistic information implied in the nature of the task. A similar conclusion was reported by Rabbitt (1982). They found that older adults do not adjust processing strategies to reflect varying stimulus location

and response probabilities which are inherent in a task, but not explicitly stated as useful in maximizing performance. In the present lexical decision experiment, older adults may not adjust their strategy to reflect the properties of the priming list as younger adults do.

An alternative hypothesis can be raised as well. Older adults are able to demonstrate the use of a strategy to facilitated response time for priming of new associations (as reported above). The presence of priming in this condition, then, may not reflect a general inability to adjust their strategy to reflect the properties of the task. Instead, older adults may be exhibiting a baseline tendency or bias to process information according to overlearned (semantic) relationships. This bias may be related to their intact semantic memory and a tendency to encode in a general or routinized fashion (Rabinowitz and Ackerman, 1982). Imposition of an episodically relevant strategy occurs only when a search of specific context is indicated by a recently studied prime.

Item Recognition

In the item recognition experiment, priming was not obtained for old associations that were not studied as pairs in either group. Instead, both younger and older adults showed highly variable reaction times and larger error rates. This suggests that under the specific retrieval requirements of item recognition, a disruption in processing occurs when a prime and target are related (e.g., GREEN

GRASS), but the target has been studied with a different word (e.g., CITY GRASS). Processing may be disrupted by a conflicting sense of familiarity ensuing when a familiar target item is presented in the context of a semantically related prime. The subject must determine if a sense of familiarity produced by the prime and target is due to previous exposure or to the strong association between the words.

This condition is analogous to the encoding specificity effect described by Tulving and Thompson (1979). The target item is not primed by the prime word because it provides a different context from that in which the target was studied. Since the prime (which was not studied) is presented first it does not elicit an initial sense of familiarity. The target is then presented within the context of the prime. The ability of the target item to activate the representation formed at encoding is diminished due to the strong semantic context provided by the prime. Thus, it is misidentified as "belonging" to the context of an old association rather than to the context of the recently studied list.

Hypothesis Three predicted age differences in this condition with only older adults demonstrating priming. This prediction was not supported in this directions; however, interesting age differences are suggested. Both older and younger subjects failed to demonstrate priming and show higher error rates in comparison to the unprimed

condition. However, older adults appear to be affected by the conflict in context to a greater degree than younger adults, as demonstrated by the larger variability in their response times and their higher error rates. This higher error rate suggests that older adults were more likely to be influenced by a target items' relationship to a related word than by its status as a previously studied item (they were more likely to reject the target as previously studied).

Both the lexical decision and item recognition tasks reveal older adults' tendency to be influenced by semantic relationship, even when contextual factors inherent in the learning task do not reinforce this information as useful. When a specific memory response is not required, as in lexical decision, the familiarity (sense that the items match or belong together) derived from the semantic relationship is not challenged. However, when a memory decision is required this familiarity is challenged. Both younger and older adults are slowed by this conflict. Older adults, though, are less able to resolve the conflict and correctly distinguish between a new memory and an old memory.

Age differences on the Shopping List Test can be interpreted as tentative support for the semantic bias. Even though older adults were asked to remember shopping list items which they had previously generated from semantic memory, they performed poorer than younger adults. Again, a deficiency in distinguishing between new information and

old information appears to be a particularly important characteristic of older adults memory difficulties.

Summary and Future Directions

This investigation was undertaken as a broad exploration of current issues raised by the implicit/explicit memory literature and the memory and aging literature. The results advance current thinking in both areas. To date there has been no adequate framework for conceptualizing and directing investigation of implicit memory for new associations. The specificity hypothesis proposed here accommodates these priming data, and describes predictable and testable relationships between task demands and the internal representation of a memory event. In addition, this framework is not incompatible with previous conceptualizations of implicit memory for preexisting representations, and in fact it may contribute to reconciling discrepancies reported with different measures of implicit and explicit memory.

The implicit/explicit memory distinction has enriched our understanding of the interactive relationship of encoding and retrieval processes, and has highlighted the importance of precisely examining the impact of deceptively subtle task manipulations. Future directions of research in the implicit/explicit memory field must continue to examine the dynamic interrelationship between various memory processes and to more carefully analyze task demands.

Further research is certainly needed to clarify the construct of specificity proposed here. It is unclear whether this construct is adequate to describe the properties of the memory representation, the retrieval cue, and the decision required in a task. The role of encoding in determining the degree of specificity inherent in a memory representation and its interaction with retrieval factors must be substantiated. In addition, comparisons of memory disordered patients with varying degrees of severity on tasks with varying encoding and retrieval demands may ascertain whether different forms of memory dysfunction exist or whether the degree of cortico-limbic disruption determines the pattern of memory performance.

A "semantic processing bias" was proposed a as a process by which older adults form less distinctive memory representations. This view must be considered speculative; however, it deserves further discussion and investigation for three reasons. First, memory processes in an older adults reflect compensatory abilities, as well as the memory deficiencies which typically receive our primary attention. Clearly, it is difficult to ascertain how a spared function compensates for and interacts with an impaired function. Nevertheless, characterizing this relationship is crucial to our understanding of information processing in any population with a cognitive impairment.

Second, characterizing this relationship is particularly important when considering the nature of aging

itself. Although many aspects of older adults' memory performance are similar to that observed in mild amnestics, the process by which this change in memory function occurs is profoundly different. In the older individual, the gradual reduction in mnemonic efficiency is intertwined with the gradual reinforcement of frequently occurring events and associations. This relationship might be expected to influence memory performance differently than an acutely occurring memory disorder.

Third, examining the interaction between knowledge and new learning more accurately characterizes how information is processed in general. Restricting our field of study to laboratory-learned stimuli has been productive, but necessarily limited in its generalizability. The approach attempted here involved placing old associations and new associations is competition for processing. Another related approach which is currently receiving attention is that of memory and inferencing (Reder, Wible, and Martin, 1986). The process of drawing inferences in response to recently presented information demonstrates an interesting interaction between knowledge and learning.

The purpose of neuropsychological research is to understand how the brain produces behavior in the rich variety and complexity that exists in humans. Our most common modus operandi is the isolation of behaviors in brain injured individuals or animals in order to determine which brain systems mediate the function of interest. Close

observation and experimentation reveals that the entirety of experience can be meaningfully divided into separate functions and behaviors.

Perhaps the biggest challenge to this reductionistic endeavor is understanding the unity of brain function in the normal healthy person. Our stream of consciousness does not include interruptions or labels which identify to us that we are engaging "memory" and now "language" or "perception". We have a unified experience. The challenge clearly lies in understanding separate functions in the context of their "natural environment"--the neurologically intact human.

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